San Elijo Lagoon Area Enhancement Plan

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Prepared by
County of San Diego Department of Parks and Recreation
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TABLE OF CONTENTS

Page

APPENDICES

LIST OF FIGURES

Page

LIST OF TABLES

SUMMARY

The study area of the San Elijo Lagoon Enhancement Plan comprises the western three miles and terminus of the Escondido and La Orilla Creek watersheds. The central focus of the plan is San Elijo Lagoon Ecological Reserve, which includes approximately 590 acres of salt marsh, brackish, and freshwater wetland habitats and 300 acres of chaparral and coastal sage scrub upland habitats. Interstate 5, the San Diego Northern Railway, and Highway 101 divide the lagoon into the east, central, and west basins. These basins are connected by narrow channels confined by bridge abutments. The inlet connecting the lagoon to the Pacific Ocean is an artificial channel confined to a sinuous alignment against the northern bluff by the railroad bridge and the Highway 101 bridge.

Over the past several decades, the biological resources of San Elijo Lagoon have deteriorated because of hydrological and land use changes to the watershed, urbanization, sedimentation, poor water quality, introduction of exotic species, and severely limited tidal action.

Even with these less than optimal environmental conditions, however, San Elijo Lagoon and the associated open space around it provide vital habitat for resident and migratory wildlife. Sensitive, threatened, and endangered plant and animal species retain a foothold here, despite increasing pressures on the system. The area is a vital coastal resource that requires attention in order to reverse decades of abuse and neglect.

The primary goal of the San Elijo Lagoon Enhancement Plan is to recommend methods to preserve and augment a gradient of self-sustaining habitats that range from salt marsh in the west basin to freshwater marsh in the east basin. These enhanced habitats will support a diverse ecosystem and satisfy regional habitat needs. The long-range plan for the area is to continue to provide for the habitat needs of wildlife while maximizing passive recreational and educational opportunities for the public.

This plan recommends increased tidal circulation to the lagoon, which would greatly restore tidal salt marsh habitat. Enrichment of brackish and freshwater marsh areas, removal of exotic species, revegetation of degraded areas, and closing of unnecessary trails through sensitive habitats are proposed to maximize existing habitat values.

1. INTRODUCTION

1.1 PROJECT BACKGROUND

San Elijo Lagoon is a coastal wetland in northern San Diego County with significant biological and interpretative resources. Its moderate climate, mixed topography, and variety of both aquatic and terrestrial ecosystems result in a great diversity of plant and animal species, including several rare and endangered species. The California Department of Fish and Game (DFG) and the San Diego County Parks and Recreation Department are the primary lagoon landowners, but several small parcels remain in private ownership. The County and DFG cooperatively manage approximately 900 acres of the lagoon area as an Ecological Reserve.

Over the past several decades, the biological resources of San Elijo Lagoon have been degrading due to hydrological and land use changes in the watershed, resulting in fill and sedimentation, introduction of exotic species, and severely limited tidal action. Limited tidal action has resulted in various perceived problems affecting hydrology, water quality, biology, and public recreation (Table 1). Several focused scientific studies of the San Elijo Lagoon and watershed have been conducted, but the area has lacked an overall comprehensive plan that analyzed existing conditions and data and recommended measures for enhancement and management. In 1989, the nonprofit San Elijo Lagoon Conservancy proposed that a detailed hydrological study be conducted that would recommend ways to increase tidal action to benefit the impaired lagoon system. In June 1989, the State Coastal Conservancy authorized $50,000 of funding to the County of San Diego to prepare the hydrological study and a comprehensive enhancement plan. This amount of funding was increased to $90,000 by the Coastal Conservancy in 1991.

The San Elijo Lagoon Enhancement Plan was developed with input from an advisory team with representatives from the County of San Diego Department of Parks and Recreation, the California Coastal Conservancy, the San Elijo Lagoon Conservancy, the Pacific Estuarine Research Laboratory, the California Department of Fish and Game, and the U.S. Fish and Wildlife Service. Philip Williams and Associates conducted the background research, field studies, and analysis for the lagoon hydrology component. County of San Diego park ranger biologists conducted the background research, field studies, and analysis for the biological component. The Pacific Estuarine Research Laboratory (PERL), associated with San Diego State University, conducted the field sampling and analysis for the benthic invertebrate and fish species section. PERL and the San Diego State University Department of Public Health conducted the field work for the water quality component. State Coastal Conservancy staff conducted the background research and analysis for the land use component. The final document was compiled and edited by staff of the County of San Diego, Department of Parks and Recreation.

TABLE 1
ADVERSE IMPACTS CAUSED BY FREQUENT LAGOON CLOSURES

1. Hydrological
   - extreme water levels
   - limited water circulation and exchange
   - limited sand supply to beach
   - siltation and sedimentation of channels
   - limited ocean inflow
   - limited channel flow and increasing constriction by invasive non-native and freshwater plants
   - cumulative effects decreasing possibility of re-opening inlet

2. Water Quality
   - low and fluctuating dissolved oxygen levels
   - low and fluctuating salinity of soil and water
   - concentration of pollutants in lagoon and sediments
   - concentration of bacteria
   - concentration of nutrients and organic debris
   - warm water resulting in high probability of algae and phytoplankton growth, high turbidity, eutrophication, oxygen depletion and invertebrate and fish kills

3. Biological
   - limited fish breeding due to lack of habitat and ocean access
   - degradation and loss of aquatic and marsh plant communities, decreasing plant species diversity and abundance
   - degradation and loss of mudflat, salt panne, and salt marsh habitat for shorebirds and endangered species feeding, roosting, and nesting
   - decreasing abundance and diversity of shorebirds and endangered species
   - invasion of salt marsh and aquatic habitats by non-native and freshwater plants
   - degradation and loss of invertebrate and fish habitat
   - invasion by non-native and freshwater predatory fish, frogs, turtles, and mammals
   - limit establishment of resident fish and invertebrate populations
   - catastrophic fish and invertebrate kills
   - impact on offshore reef community with intermittent openings

4. Public Services and Safety
   - Private property and roadway flooding
   - Reduced recreation opportunities, including:
     - trail flooding limiting access
     - loss of sand on State beach
     - cobble build up on beach
     - reduced water quality and increased beach closures

TABLE 1 (cont.)

  - odors impact campground
  - limited environmental education programs due to unpredictability, habitat and species loss
- High bacteria levels and mosquito populations present public health risk
- Increased administrative time dealing with complaints on health and nuisances, emergency scheduling, permit applications
- Loss of support from adjacent homeowners due to odors, insects, etc.
- Limited gamefish populations
- High populations of nuisance midges

1.2 PROJECT GOALS AND OBJECTIVES

Following are goals and objectives developed by the advisory team for the enhancement of the natural resources of the San Elijo Lagoon area:

Goal

To protect, maintain, and enhance the San Elijo Lagoon system and adjacent uplands in order to perpetuate native flora and fauna characteristic of southern California; to restore and maintain estuarine hydrology.

Objectives

1. Open the lagoon mouth regularly or maintain open permanently, to enhance the health and ecological value of the lagoon.

2. Provide a natural gradient of habitats from saltwater marsh in the western end to riparian and upland systems in the eastern end of the study area. Emphasize restoration of a viable salt marsh system.

3. Design and implement a plan to improve circulation in areas of historical tidal action. Ensure adequate water quality and salinity to maintain the long-term viability of the lagoon habitats.

4. Enhance habitats for native species including, but not limited to, rare and endangered species.

5. Avoid the disturbance of cultural resources.

6. Develop public access opportunities consistent with resource protection. Develop community education programs about the natural resources of the area.

7. Develop a cost-effective management and maintenance plan for supporting the proposed habitat enhancements.

8. Design and implement a biological and hydrological monitoring program to develop a data base on which to base future decisions and to assess the success of restoration efforts.

9. Improve water quality through restored tidal circulation to reduce: a) impacts to public recreation from beach closures, b) health risks from high bacteria counts when the lagoon is tidal and the beach is open, and c) potential for mosquito-borne diseases.

1.3 PHYSICAL DESCRIPTION OF THE PROJECT SITE

San Elijo Lagoon is a coastal wetland located in San Diego County between the cities of Solana Beach and Encinitas, 20 miles north of the City of San Diego (Figure 1.1). The watershed draining into the lagoon is 77 square miles with two main tributaries, Escondido Creek (72 square miles) and La Orilla Creek (5 square miles). Freshwater inflows to the lagoon are limited by Lake Wohlford and Dixon Lake in the Escondido Creek drainage and San Dieguito Reservoir in the La Orilla Creek drainage.

The focus of the San Elijo Lagoon Enhancement and Management Plan includes the area bordered on the north by Manchester Avenue, on the west by the Pacific Ocean, on the south by coastal bluffs, and on the east by the residential areas west of El Camino Real. Although the main focus of the data is on the Ecological Reserve properties, upland and watershed areas are also considered to the extent that they affect the viability of reserve habitats (Figure 1.2).

Highway 101, the San Diego Northern Railway (SDNR), and Interstate 5 divide the lagoon into three basins connected by narrow channels (see Figure 1.2). The west basin, the area between the Pacific Coast Highway and the railroad, contains 45 acres of wetlands that form a series of four to five ponds. The central basin between the railroad and Interstate 5 constitutes 220 acres of shallow open water and mudflats, diked areas formerly used for sewage oxidation or duck hunting, and a sinuous channel along the northern shore. The east basin, east of Highway 5, contains approximately 257 acres of shallow fresh and brackish wetlands, including salt marsh and salt panne. The basins exhibit the varying salinity regimes and habitats within the lagoon, generally grading from most saline (>20 ppt) in the west basin to brackish in the central basin (usually 10-20 ppt) to nearly fresh in the upper end of the east basin. The California Department of Fish and Game has dredged two circular channels to create least tern nesting islands in the east basin. The water level in these channels is controlled by flood gates in the two culverts through a dike.

In addition to the wetlands, the San Elijo Lagoon Ecological Reserve study area contains approximately 300 acres of upland habitat. Both the central and east basins have chaparral and coastal sage scrub habitats on the upland slopes to the south.

1.4 REGIONAL PERSPECTIVE

San Diego County's wetlands are among the most threatened natural resources on the California coast. By 1900, human influence from agriculture and urbanization had modified all 16 of the county's coastal wetlands. San Diego's north county coastal wetlands have been partitioned into several separate bodies of water by fill and bridges for Interstate 5, Highway 101, El Camino Real, and the railroad. These constrictions prevent the migration of the entrance channels, slow water velocities, and decrease the power of the ebb flow to scour sand. As a result, many of San Diego County's lagoons are rarely open to the ocean.

Since the 1970s, the purchase of many of these areas with public funds for wildlife preserves, as well as regulation of coastal development, has slowed wetland losses. However, the County's population growth (35-40 percent in the 1980s) and the associated construction boom has caused

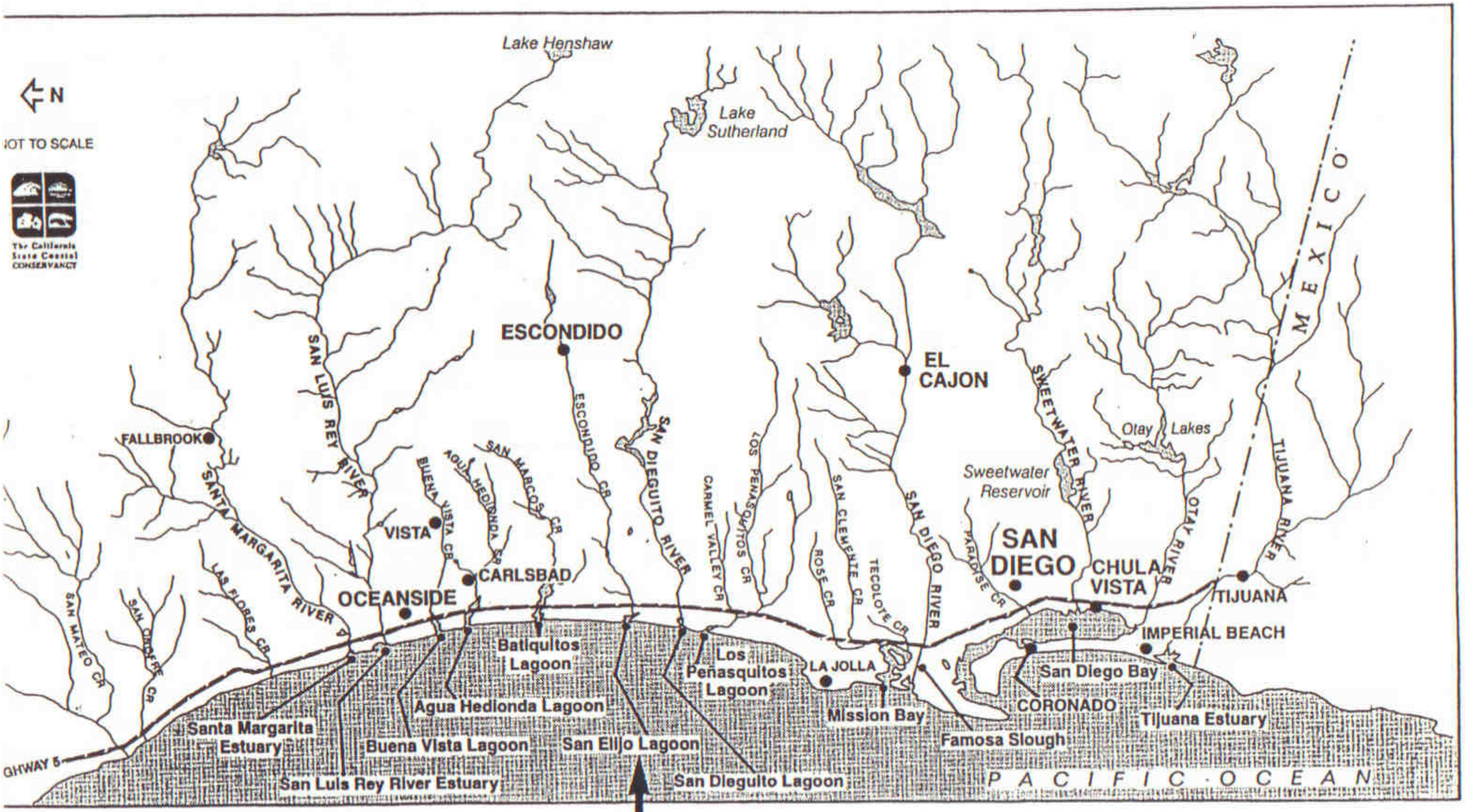
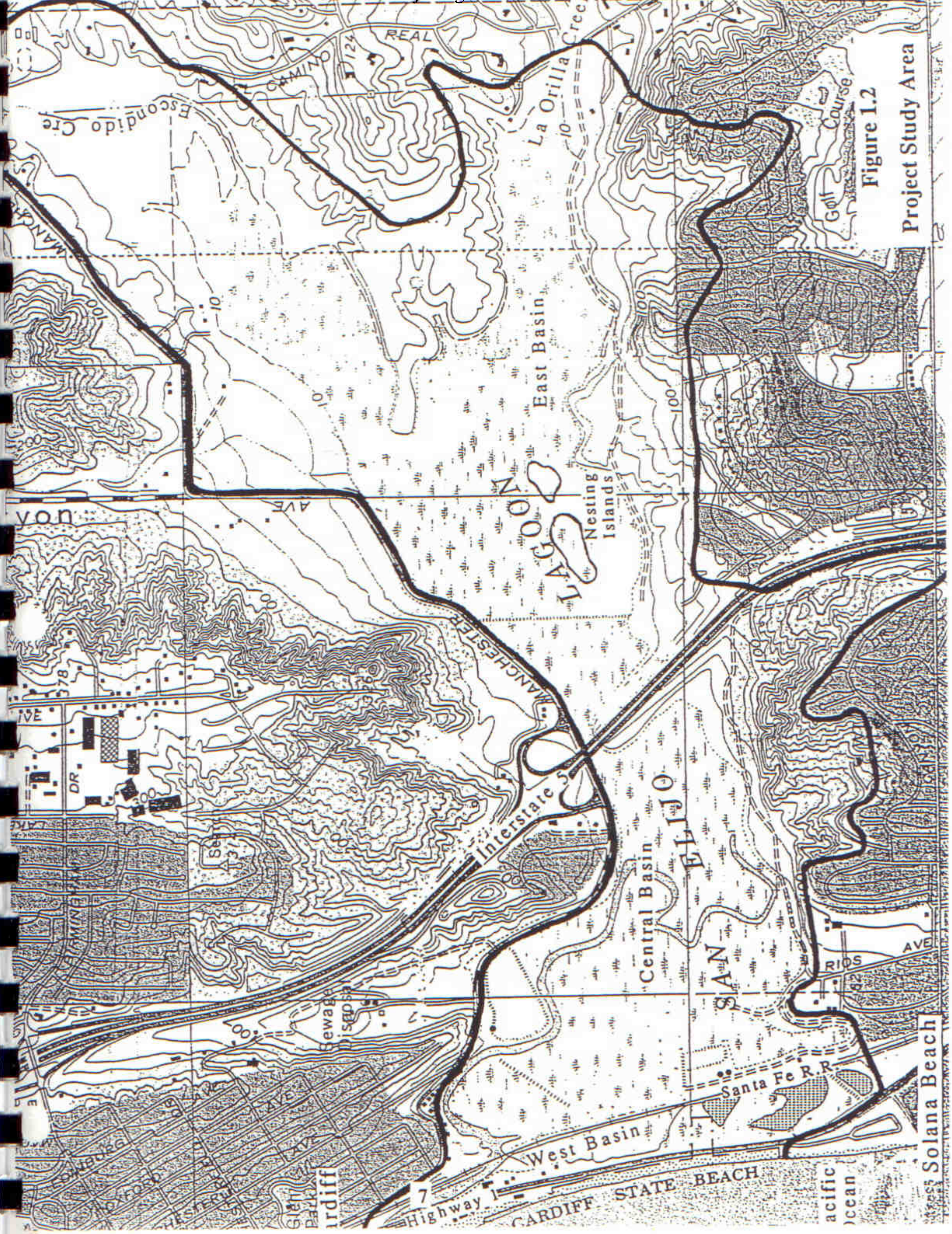


Figure 1.1

Location Map of San Elijo Lagoon and Watershed

Exhibit 3: San Elijo Lagoon Area Enhancement Plan



increases in graded land and erosion in coastal watersheds. Coastal wetlands are the endpoints of these watersheds, and they are filling in with sediment. In addition, construction of dams and reservoirs on most major coastal streams has reduced the amount and frequency of flood flows, which has reduced the flushing of sediment from estuaries. Releases of freshwater from upstream reservoirs, sewage treatment works, and urban runoff during the summer months have caused major salinity and nutrient changes in coastal wetlands. Unless future development is guided to protect wetlands and watersheds together as a system, San Diego's coastal wetlands and their wildlife as we know them will soon disappear entirely.

Southern California coastal marshes are confined to narrow stream outlets along a coastline of rugged topography and continuing geological activity. The Mediterranean climate of the region provides little rainfall, on the average, so that tidal seawater is the major source of moisture throughout all but the brief winter wet season. Sand deposited by longshore currents tends to build up along the ocean inlets, and wetlands with small tidal prisms are likely to become completely closed to tidal circulation. Various land use practices reduce tidal prisms, which in turn increase the probability and duration of lagoon closure. Extreme variations in intertidal soil salinities occur between years of flooding and drought. Lagoon closures cause additional variability in salinity. Large areas of southern California marsh habitat are hypersaline throughout the spring to fall growing season. The wide ranging salinities and long periods of hypersaline conditions contrast greatly with brackish tidal marshes elsewhere in the United States (Zedler 1984).

San Elijo Lagoon lies between San Dieguito Lagoon to the south and Batiquitos Lagoon to the north. The 77-square-mile watershed draining into San Elijo Lagoon is midrange relative to the watersheds of the other coastal wetlands. Like other north county lagoons, San Elijo's hydrological problems are compounded by the current sand/cobble imbalance on the beaches.

The coastal wetlands of San Diego County contain a variety of plant and animal species. Different environmental conditions such as marsh elevation, salinity, water temperature, water quality, and duration of inundation determine the types of biota that occur at each estuary. Many species that inhabit marshes could not live in any other type of habitat. Therefore, as wetlands have become threatened, so have the associated species. Most of San Diego's coastal wetlands support endangered plant and animal species. San Elijo Lagoon Ecological Reserve serves a particularly important function in the region as home to 45 sensitive species.

Many of the migratory bird species utilizing the Pacific Flyway depend upon the health of these wetlands. Several researchers believe that the birds make use of different San Diego coastal wetlands during the winter, depending on which one has the right conditions to produce a large food base. Since each wetland varies in the type of habitat it contains, different species will concentrate in different lagoons or bays, making each wetland and its continued health an essential factor in the survival of these birds.

1.5 LAND USE

1.5.1 Historic Land Use (10,000 Years BP to 1880)

Native groups representing the San Dieguito, La Jolla, and Diegueño Indians occupied the San Elijo Lagoon area from 10,000 years before present to the historic period. The activities of their cultures had a minor impact on the hydrological, geomorphic, and biological evolution of the lagoon. The hunting and gathering lifestyle of the resident people probably reduced populations of some plant and animal species, and may have fostered others. It is likely that brush fires were frequent, as native peoples are known to have actively managed vegetation for game and certain food plants.

San Elijo Lagoon was named in 1769 by the Portola Expedition on its way to Monterey. Spaniards and other Europeans settled in the region and established cattle ranches in the early 1800s, and the population grew rapidly after 1848 with the discovery of gold in California. Early permanent Anglo settlements were established in the 1880s. The community of Olivenhain on Escondido Creek, established as an experimental farming community, was an influential force in the area. This marked the start of a period of radical vegetation shifts and land conversion. Riparian areas seem to have been especially modified. During this time, cultivation of sandy coastal soils encouraged the replacement of native bunch grasses with non-native, annual species.

1.5.2 Current Land Use (1880 to present)

1.5.2.1 Physical Modifications to Lagoon

After the 1880s, human modifications to the hydrological system of the San Elijo Lagoon area accelerated at a rapid pace. Several dikes and levees were constructed between 1880 and 1940 to create access roads, duck ponds, and sewage treatment ponds. The partitioning of the lagoon and restricted tidal action altered natural flow paths and led to an accelerated rate of sediment deposition, and subsequent impairment of the water quality of the lagoon.

A berm and bridge crossing the lagoon near the mouth was completed in 1887 to support installation of the Santa Fe Railroad. This construction reduced the connection between the lagoon and ocean to a narrow channel. The inlet channel was further confined to the northern end of the beach in 1891 with the construction of a plank road, the present day Highway 101, built on what would have been barrier dunes along the ocean. The present SDNR railroad bridge was constructed in 1925, reducing the inlet channel width from approximately 500 to 250 feet. The existing bridges for Highway 101 were completed in 1932, further confining the inlet channel. In 1934, more fill was added to support the railroad. In 1965, Interstate 5 was constructed, dividing the wetland area in half. In 1981, the California Department of Fish and Game and the County of San Diego built the east basin water management project to manipulate water levels for flood and mosquito control. The project included restoration of a dike and installation of water control gates, two concrete spillways and a pond with two least tern nesting islands. In 1985, the elevation of Manchester Avenue was raised to reduce the flood frequency on the road. Prior to 1985, the lagoon was artificially opened mainly to allow Manchester Road to remain passable during times of high water in the lagoon.

1.5.2.2 Freshwater Inflows

In addition to the alteration of the natural flow of water by transportation corridors and dikes, other changes have occurred in the San Elijo watershed that have modified the natural salinity gradient in the marsh. Natural freshwater inflows to the lagoon were reduced to ephemeral surface flows as a result of the construction of reservoirs on Escondido Creek. The dam for the largest reservoir in the watershed, Lake Wohlford, was completed in 1924. During this period, the east basin dried out and became a salt flat where salt was harvested.

Between 1940 and 1973, wastewater was discharged from local sewage treatment plants into Escondido Creek and the lagoon itself, causing a shift in the lagoon from saltwater habitat to a more brackish system. Cardiff and Solana Beach sewage treatment plants discharged into the lagoon from 1940 until 1966, after which the wastewater was discharged through an outfall into the Pacific Ocean. Between 1959 and 1973, the City of Escondido discharged treated wastewater into Escondido Creek at the rate of 3.5 million gallons per day (mgd). Estimates are that approximately 2.5 mgd reached the east basin as surface flow (Watkins 1987). This treated effluent was diverted into ponds in the lagoon to provide further treatment, waterfowl habitat, and hunting opportunities. These dikes have eroded gradually, and in 1971 hunting was discontinued in the lagoon. In 1973, the County of San Diego upgraded the wastewater facilities. Currently, the treated wastewater from Solana Beach, Cardiff, and Escondido is discharged through the San Elijo outfall to a distance approximately 1.5 miles offshore. The San Elijo outfall is managed by the San Elijo JPA, consisting of the Cardiff and Solana Beach Sanitation Districts. In late 1991, the JPA funded reinforcement of the existing outfall offshore.

Recorded sewage spills into the lagoon occurred from overflows at the San Elijo Treatment Plant (which is located on the north side of Manchester Avenue adjacent to the central basin), into Escondido Creek from the Escondido treatment facilities, ruptures of the Escondido line adjacent to Manchester Avenue, or from blockages at any of several sewage pump stations around the creek and lagoon. In addition to an increase in freshwater inflows, sewage spills have probably contributed to the excessive nutrient levels and high counts of fecal coliform that have been measured in the lagoon.

Due to factors such as the cessation of the effluent from Escondido and the deepening of channels to keep minor stream flow from spreading over the flats, some of the freshwater areas of the marsh in the east basin have been drying out and changing into seasonally dry marshes. Soils east of the flood control dike have dried out in the summer months. The salt concentration there has increased and freshwater vegetation has been replaced by more salt tolerant species.

Although recent field observations have shown that some of the minor tributaries may be perennial due to urbanization and irrigation, the small flows observed are insufficient to compensate in these areas for the cessation of the wastewater or the reduction in natural flows due to the upstream dams.

However, in other areas of the reserve that would ideally be salt marsh (the western end of the central basin and the west basin), urbanization is increasing the freshwater flow through storm drain discharges, and freshwater species are once again encroaching.

1.5.2.3 Watershed Development

Human construction activity in upland areas surrounding the lagoon has directly and indirectly modified the ecology of the lagoon. Discharge patterns, volumes, and velocities of storm waters have changed as land has been altered. Areas paved for roads, parking lots, etc., no longer absorb rain, and this increase of impermeable surfaces causes larger volumes of water to be discharged to the lagoon in a shorter period of time. Any development within the Escondido Creek watershed directs its storm drain run-off to Escondido Creek. Solana Beach, Cardiff, and Encinitas storm drains discharge directly to the lagoon. This causes intensified seasonal flooding within the wetlands, with increasing impacts to plants and animals living in low areas.

Increased artificial irrigation within the watershed has resulted in minor flows during the summer, something that had almost ceased with the construction of Lake Wohlford and cessation of effluent discharge. This water, however, is often nutrient-rich runoff from lawns, poultry ranches, pastures, dairy farms, and urban areas, and it contains more concentrated nutrients than the episodic storm events. As a result, algae is stimulated, often to periodic bursts of rampant growth, which are referred to as "blooms." Such conditions can lead to eutrophication of the aquatic system as the algae dies and decays. This results in anaerobic conditions in the water column, to the detriment of creatures living there. Additionally, these year-round inflows of fresh water reduce the overall salinity of the lagoon and sediments, resulting in invasion of freshwater plant species in areas previously supporting salt marsh.

While nutrients are one form of water pollution entering the lagoon ecosystem, urban and rural runoff can also contain pesticides, heavy metals, and other harmful chemicals. These chemicals enter the system inadvertently as contaminants deposited on impermeable surfaces that are then washed into the drainage by rain, or they are illegally dumped or discharged into storm drains. Such substances may include motor oil, gasoline, or the chlorinated water from swimming pools.

Coastal urbanization has resulted in the rapid loss and degradation of wetlands, salt marsh in particular, but also of the upland plant community, coastal sage scrub. Found mainly on the coastal plain where climate and terrain are agreeable for human habitation, this community is home to many plants, birds, mammals, and reptiles now considered to be threatened or endangered because of habitat loss. Fragmentation of this habitat is also a concern; isolated "islands" of habitat under a certain size soon lose their species diversity as top predators such as coyote and bobcat are excluded by reduced foraging range, human hunting and trapping, and mortality on roadways. This allows non-native predators (e.g., cats, rats, opossums, and dogs) and midsize, native predators (raccoons, foxes, and skunks) to proliferate, thereby adversely impacting the populations of small, often endangered, prey species.

2. EXISTING CONDITIONS

2.1 LAGOON AREA GEOLOGY

2.1.1 GEOMORPHIC EVOLUTION OF THE LAGOON

The geology of the project site has been described in the San Elijo Lagoon East Basin Water Management Plan (1976), the San Elijo Lagoon Regional Park Master Plan (1977), and the Draft Environmental Impact Report for San Elijo Lagoon Regional Park (1979), and by Abbott (1982).

Cretaceous metavolcanic and granitic rock underlay the lagoon basin. Overlaying the lagoon basin is approximately 150 feet of alluvial clay and silts. The alluvium consists of an upper layer of organic and silty clays (maximum depth is 16-26 ft.), and a lower unit of fine to coarse sandy silts (approximately 130 feet thick).

Bordering the lagoon basin and lower reaches of the principle tributary, Escondido Creek, are steep bluffs rising 50-350 feet NGVD (National Geodetic Vertical Datum or mean sea level). These bluffs are composed of tertiary marine sediment deposits of sand, shale, and sandstone. The marine sediment formations are predominantly Del Mar and Torrey sandstone (from the Mid-Eocene period - 47 million years ago) topped by Linda Vista red sandstone (from the Pliocene-Pleistocene period - 1.6 million years ago).

The Del Mar Formation is the lowest stratum of the bluffs, characterized by a yellowish-green, sandy claystone. This formation reaches approximately 250 feet NGVD and is overlain by a 5-25 ft. layer of mudstone. A representative exposure can be seen in the roadcut on Manchester Avenue, just west of the turnoff to the sewage disposal plant. A number of resistant, fossiliferous (brackish water mollusks) beds occur locally near the present lagoon, toward the top of the formation. Overlaying the Del Mar Formation is the Torrey Sandstone Formation, a white to light tan, medium to coarse-grained sandstone that is generally cross bedded. Capping the Torrey Formation is the Linda Vista Formation, a reddish brown, interbedded sandstone and conglomerate. Hematite cement gives the Linda Vista its color and resistant nature. A good exposure of the Torrey and Linda Vista formations can be seen in the canyons just west of I-5 on the south side of the lagoon. The characteristic colors of the three formations make the outcrops easily recognizable.

Thick marine sediments were laid down over the project area between 45 million and 1.6 million years ago when ocean levels were much higher than at present. Between 5,000 and 18,000 years ago, a period of glacial extremes created ocean levels approximately 400 feet below current levels. During the past 1,500 years, the sea level has been relatively stable, although regional studies on the effects of global warming indicate that sea level can be expected to rise by 2-3 ft. during the next 100 years.

2.1.2 Sedimentation

In the 1990 Water Quality Assessment, the San Diego Regional Water Quality Control Board (RWQCB) identified 150 acres of the 330-acre San Elijo Lagoon as having a water quality condition rating as impaired. The RWQCB determined that this degradation was caused by eutrophication and accelerated sedimentation. Much of the lagoon's degradation from excess sediment can be attributed to past activities such as construction, agriculture, road building, and creation of other obstructions to natural tidal flows (Soil Conservation Service 1993).

The Soil Conservation Service (SCS) has identified the following problems associated with excess sedimentation in San Elijo Lagoon:

- Contains toxics, nutrients and pesticides
- Detrimental to the health and habitats of aquatic life
- The shallow lagoon affects the diversity of species and their numbers
- Increased sediment deposition reduces tidal flushing
- The loss in suitable habitat reduces coastal fish numbers
- Loss of wetlands from filling in of lagoon
- Loss of recreational area and aesthetics
- Loss of forage and habitat for threatened and endangered species

In this report, "Section 2.2.5: Water Quality" discusses in detail the effects excess sedimentation has on water quality of the lagoon system.

Foster (1991) conducted a sediment study to gather data on the major historic floods of 1862, 1916, 1938, and 1969. The study included core sampling and analyses of these samples to provide information on the depth of sedimentation during the major floods and more accurate data on the long-term sedimentation rate in the lagoon. The results of this study should be available in 1996.

In 1993, the Soil Conservation Service conducted a study for the State Water Resources Control Board to identify methods to minimize nonpoint pollution source loading in the San Elijo Lagoon watershed (SCS 1993). The report identified the various land uses in the San Elijo Lagoon watershed and quantified an average amount of erosion and sedimentation generated by each land use. Total erosion and sediment figures were estimated for 33 land use types and stream channels in 12 subwatersheds. The average annual rate of sediment yield was estimated to be about 40,000 tons per year with about 30,000 tons being deposited in the lagoon and 10,000 tons being transported to the Pacific Ocean.

Much of the sediment delivered to the lagoon has been from past activities, when construction and agricultural activities were high. The report notes that the overall rate of erosion has decreased as the rate of construction has slowed, the acreage of agricultural land has decreased (about 70%), and some conservation practices have been initiated.

2.1.2.1 Sources of Sediment

Erosion of gullies provides a significant source of sediment for the lagoon. Roads, agriculture, and unvegetated construction areas accelerate the erosion rate and subsequent sedimentation of the lagoon. The most significant sources of sediment were identified by the Department of Public Works, San Diego County in the Erosion and Sediment Study (Barry et. al. 1976) (Figure 2.1) and the Soil Conservation Service (1993). There has been no measurement of the precise sediment budget from the surrounding watershed, although the Soil Conservation Service has estimated approximate sedimentation rates associated with identified land uses in subwatersheds.

Escondido Creek and, to a lesser extent, La Orilla Creek are the principal transporters of alluvial sediment.

2.1.2.2 Sediment Size Distributions

The nature of the bed sediments in San Elijo Lagoon was determined by collecting sediment samples at 17 locations throughout the lagoon. Surface samples and samples up to one foot beneath the surface were inspected. The results of this limited survey are tabulated in the Hydrology Appendix and show that the coarsest sediment is found on the barrier beach. Large cobbles were also observed to be an integral part of the barrier beach, and these larger elements inhibit scouring of the channel at low tidal flows. Fine sand was observed in the sediment deposits in Lux Canyon and in Escondido Creek. Finer material was observed at the confluence at La Orilla Creek and in the southern part of the central basin adjacent to the bluffs. The finest material was observed in the central basin, and the bed surface of the channels in this area was covered by a depth of 1-10 in. of mud sludge. This source of this material is due in part to the past wastewater discharges into the lagoon. The shallow, broad nature of the central basin and sinuous channels of the main marsh channel enhance the settling of fine sediments and organic material as water slows down in this region.

2.1.2.3 Sedimentation Rates

San Elijo Lagoon's rate of sedimentation has not been measured, but the Soil Conservation Service has estimated it to be 30,000 tons per year. Foster (1991) drilled four exploratory boreholes in the east basin, and the well logs and subsequent dating procedures should yield some information on the historic sedimentation rates.

The SCS report estimates that average annual erosion rates from the different land uses in the vicinity of San Elijo Lagoon vary from zero to eight tons/acre/year. Average natural rate of

Exhibit 3: San Elijo Lagoon Area Enhancement Plan

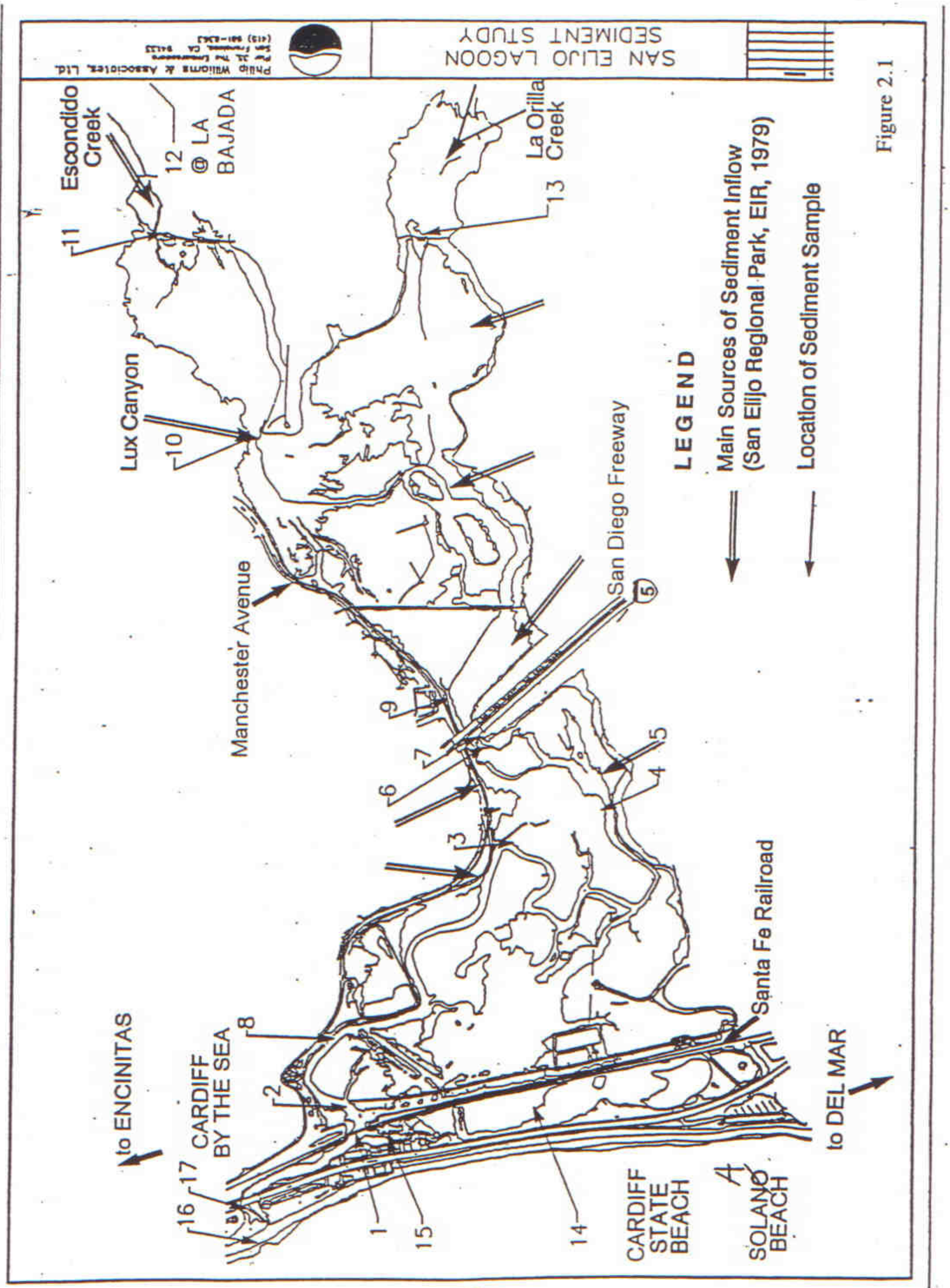


Figure 2.1

erosion for the San Elijo Lagoon hydrologic area was estimated at less than 0.5 tons per acre per year. The SCS estimated that the total sediment delivered to the lagoon from all sources is approximately 30,000 tons/year. If the sediment is assumed to settle evenly throughout the entire lagoon, the average annual sedimentation rate would be 0.3 inches/year.

In 1978 Daniel and Lowry estimated a sedimentation rate of 0.14 inches/year. The sedimentation rate has probably increased during the past two decades due to the failure of Val Sereno Dam and the rapid rate of urbanization with the watershed.

Future surveying of the monumented cross-sections established in 1991 will provide more information on the sedimentation rate.

2.1.3 Soils

Most of the soils in the San Elijo Lagoon area are subject to severe erosion. As noted in the San Elijo Erosion and Sediment Study (Barry et al. 1976), runoff from various nearby housing developments aggravates erosion and sedimentation. The erosion problem warrants critical examination in any land use planning for the area.

2.2 LAGOON HYDROLOGY

Prior to the 1880s, San Elijo Lagoon was a low-lying marshy plain. At high tides, ocean water flowed through the entrance channel and reached eastward to what is now El Camino Real. Fresh water, flowing freely down Escondido and La Orilla creeks, carried sediments to the ocean. The mouth of the lagoon migrated from year to year, breaching the wave-deposited sand berm at its lowest point. The result of this constant, unimpeded exchange of fresh and salt water was a stable wetlands.

This natural state of hydrologic equilibrium was destroyed in the 1880s when manmade obstacles began to be constructed. Over the last century, transportation corridors, dikes, impoundments, and buildings have altered the natural flow of water to the sea, causing it to slow down, stop, or back up. As the velocity of this ocean-bound water decreases, suspended material falls out before it reaches the sea. Over time these sediments build up, making the lagoon shallower. With less depth, the lagoon holds less water and cannot breach as frequently.

The body of water that flows into and out of the lagoon with each tide cycle is known as the tidal prism. With the capacity of the lagoon to hold large volumes of water reduced by sedimentation, the tidal prism has been reduced. That becomes especially significant when coupled with the confinement of the lagoon entrance to a fixed location under Highway 101. Under natural conditions, the tidal prism was sufficient to break through the beach berm at its lowest point on a regular basis. But confinement of the entrance means that it cannot migrate to this lowest point, and the tidal prism, now reduced by sedimentation, is insufficient to breach the berm as frequently at the fixed location. The result is a lagoon closed to the regular exchange of fresh and salt water, with a concomitant change in flora and fauna.

Built-up sediment also affects lagoon hydrology by acting like a physical barrier that inhibits the flow of salt water into the eastern basin. As the tide comes in, water fills the channels and spreads over the flats of the central basin. The salt water must gain enough elevation in the central basin to rise over the sediment west of Interstate 5. Except at extremely high tides, this does not occur.

At several points near Interstate 5, the railroad bridge, Highway 101, and the flood control dike in the east basin, the flow of fresh water is accelerated artificially. As the ocean-bound water reaches these obstacles and is constricted into narrow channels, its velocity increases until it passes the obstacle and fans out over the flats. Incoming tides are usually insufficient to overcome this accelerated freshwater flow. The result is that salt water is confined to the west and central basins, and salinity levels east of Interstate 5 generally remain around the level of fresh water.

Lagoon hydrology is also affected by freshwater runoff from storm drains and streets, often from historically new directions. The result is an alteration of the natural distribution and diversity of the flora and fauna in the lagoon. Pollutants brought in with this runoff also have a detrimental effect on the lagoon ecosystem.

2.2.1 Lagoon Mouth Opening Characteristics

Geological studies have indicated that the lagoon was once a fully tidal system connected to the Pacific Ocean by a migrating channel. The volume of the lagoon appears to have decreased during the past 100 years, but there is no clear historical record stating whether the earliest settlers observed a lagoon that was always open to tidal circulation, or one which was closed periodically. In 1887, there were several channels breaching the barrier beach, although the frequency of opening is unknown.

The State Lands Commission has summarized the historic records for San Elijo Lagoon. The 1881 GLO Township Plot defined San Elijo Lagoon as salt marsh, although the field notes make no reference to the lagoon opening condition. The 1887 USC&GS Chart #T-1898 depicts marsh from the inlet to a point 3,000 feet inland. The 1901 USGS Oceanside Quad shows the lagoon being closed to the ocean, but the entire lagoon is covered with marsh symbols. A 1934 USC&GS map (#T-5411, from an air photo compilation) also shows the lagoon entrance being closed, but the photographs for the compilation were taken when the lagoon was open. The survey notes indicate that the mouth of the lagoon would close routinely by wave action and deposition of a sand bar during the dry seasons. The lagoon filled with fresh water during the rainy season until it breached and returned to tidal influence. This information implies that the lagoon has been closed periodically during the past 100 years.

The first map of the lagoon on record was drawn in 1887, and the associated field notes reported that the lagoon was crossed by the railroad with a narrow bridge and a 1000-ft. long levee. It was noted that these man-made obstructions had inhibited the tidal action and the lagoon entrance was no longer open permanently to the Pacific Ocean.

San Elijo Lagoon is now connected to the Pacific Ocean via a narrow and sinuous inlet channel that passes under the railroad bridge, turning north to parallel the beach before turning west under Highway 101 and across the barrier beach. Migration of the inlet channel is inhibited by rip-rap in the regions around the bridge abutments and railroad easement. Development on either bank has restricted the inlet channel width to approximately 400 feet. Development along Highway 101 and the stabilization of the Highway 101 roadway itself have precluded natural channel migration for many years. Economic investment in existing structures and facilities encourage confinement of the channel to its existing bed, to the detriment of the lagoon's flora and fauna.

Figure 2.2 compares the type of inlet conditions that may exist in coastal lagoons in California. Type I lagoons are normally open to tidal action, whereas Types II and III are closed for periods of time. Johnson (1973) identified the principal process governing the lagoon entrance condition as longshore sediment transport and the scouring action of tidal flows in the inlet channel. Longshore currents provide sediment to block the lagoon entrance, and wave run-up controls the height of the barrier beach. The scouring action of the tidal currents in the inlet is proportional to the total volume of water passing in or out of the lagoon in a given tide cycle. This tidal prism is illustrated in Figure 2.2.

Calculations for San Elijo indicate that the inlet condition is expected to be open only rarely, which is verified by field observations (see Hydrology Appendix).

The natural mechanism of lagoon breaching is illustrated in Figure 2.3. The inlet will close, and the height of the barrier beach will be determined by the maximum elevation of wave run-up. Water is lost from the lagoon through transpiration from plants, evaporation from the open areas of water, and seepage under the barrier beach. If these losses exceed the freshwater inflow, the water surface elevation of the lagoon will decrease. Conversely, if the freshwater inflow exceeds the losses, the water surface elevation will increase, until the elevation is sufficient to overtop the barrier beach. The barrier beach is then eroded by the escaping water and the lagoon drains. The lagoon will remain open to tidal action until the wave action moves sufficient sand and cobble to block the inlet again.

There have been twelve natural breaches between 1986 and 1993, although the artificial breaches precluded some natural breaches from occurring (Hydrology Appendix). This is discussed further in Section 2.2.3.

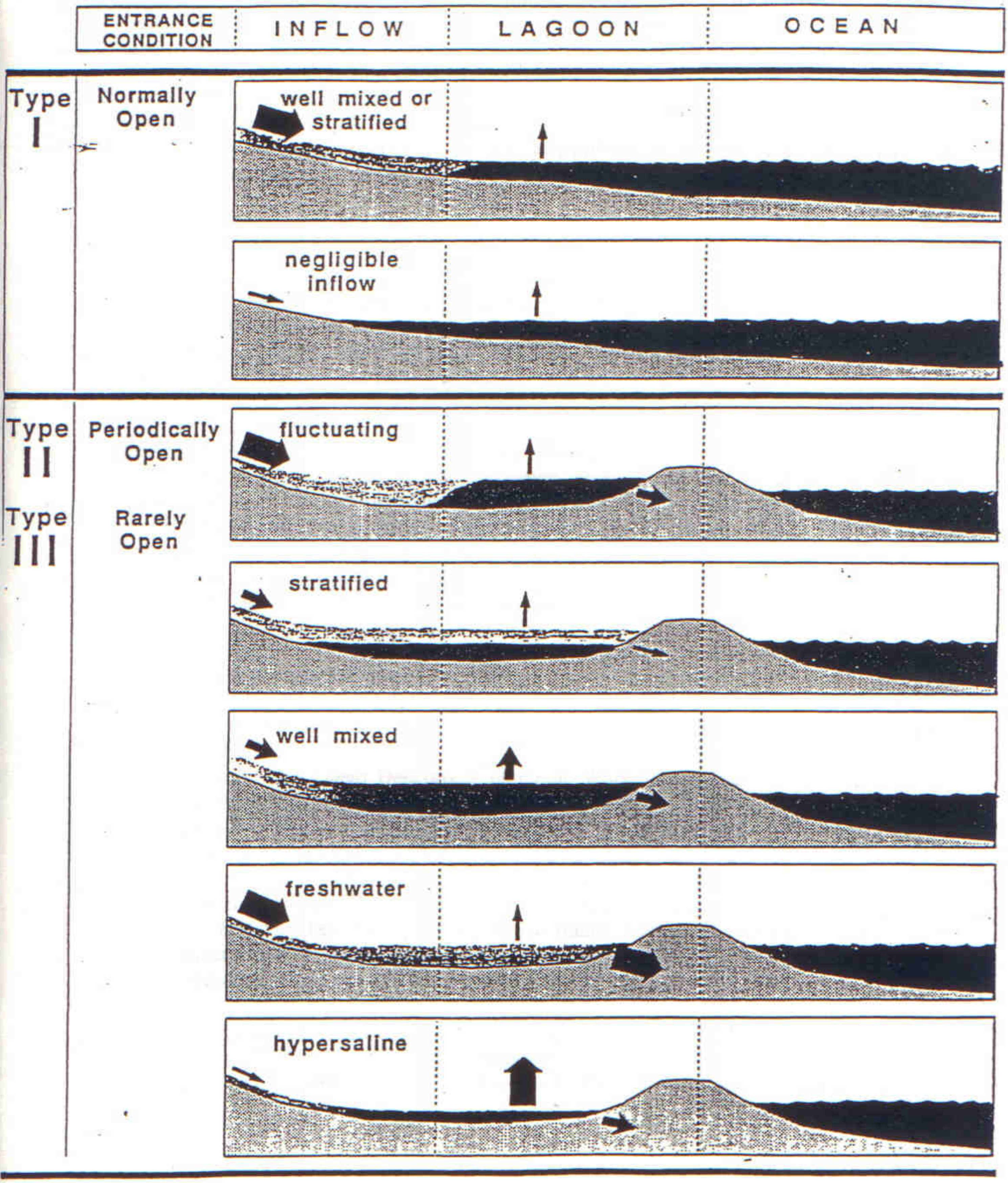
Previous attempts at artificial breaching of the lagoon by the Department of Parks and Recreation have shown the need for a large volume of water in the lagoon to establish an inlet channel sufficient to allow tidal flows, unless the channel is deepened through the surf zone.

Philip Williams & Associates, Ltd.

Tidal Inlet Conditions, San Elijo Lagoon, October 1990

Figure 2.2

Types of Coastal Lagoons in California



Philip Williams & Associates, Ltd.
Consultants in Hydrology

Types of Coastal Lagoons in California

Figure 2.3

Cobble requires considerable energy to move, and the force of outgoing water may be insufficient to move these large stones. Generally, breaching the beach berm at low water elevations does not scour the inlet channel to a depth sufficient to remain open for more than a few tidal cycles. Should the barrier berm return to a predominately sand condition, breaching of the lagoon would be facilitated, as sand moves more readily than cobble when scoured by water. Excavations of the beach and surf zone in 1994 and 1995, funded by USFWS grants, indicate that removal of 6,000 to 7,000 cubic yards of cobble and sand in the spring can prolong tidal exchange well into summer.

2.2.1.1 Lagoon Characteristics

Numerous other factors affect the hydrology of the lagoon. Highway 101, the San Diego Northern Railway, Interstate 5, and the east basin flood control dike all impair channel development and migration by confining water flow at culverts or bridge underpasses. Sedimentation patterns and rates are radically affected by these obstructions.

Less obvious, but equally disruptive to channel development and unimpaired water circulation, are the numerous islands distributed throughout the lagoon. Formed by dredging or through sediment deposition, they can obstruct freshwater flows and can slow and divert salt water at the upper reaches of the high tide within the lagoon. Examples of these islands include the linear islands formed by dredge spoil during installation of the sewage outfall, old impondment structures from sewage treatment operations, and sediment islands. These latter are particularly obvious west of Interstate 5, where reduced velocity of storm waters below the freeway constriction allows sediments to settle out.

2.2.2 Freshwater Inflows

2.2.2.1 Low Flows

The County of San Diego Department of Public Works has operated a streamflow gauging station at Harmony Grove Road since 1970. Streamflows were recorded at Olivenhain between 1971 and 1973. There are no streamflow records for Escondido Creek or La Orilla Creek at the point of inflow to San Elijo Lagoon.

Following the termination of effluent discharges into Escondido Creek, the only significant source of inflow has been from precipitation and runoff. Historically, Escondido Creek has been an ephemeral stream, but recent observations during this study have indicated that small flows from urbanization now continue for most of the year.

The City of Escondido has considered releasing reclaimed wastewater into Escondido Creek, which could significantly increase the freshwater inflow. However, there are no active plans to discharge into the creek in the foreseeable future (Patricia Borchmann, Planning Department, City of Escondido, pers. comm. 1991). The potential impacts of this unknown volume of fresh water have not been investigated. The inflow of any volume of fresh water into a closed lagoon will be detrimental to the marine system. If the lagoon is open to the ocean, this inflow may have less impact. Any proposal to increase the discharge of fresh water to Escondido Creek should thoroughly address the environmental impacts to the lagoon system.

2.2.2.2 Storm Events

There are no official records of past floods, although the U.S. Army Corps of Engineers (1972) identified the floods of 1916, 1927, 1937, 1945, 1965, and 1966 from newspaper accounts as causing flood damage. The major storm of 1980 is also known to have caused some damage, including the failure of Lake Val Sereno dam in Olivenhain. The peak flow that would occur in a 100-year flood event is estimated to be 22,000 cfs (Bradley & Associates, 1989; FEMA, 1989). Generalized peak flows for flood events are shown in Table 2.

2.2.3 Water Balance for San Elijo Lagoon

The volume of water stored in the lagoon depends upon the tributary inflows, direct precipitation, groundwater contributions or losses, evapotranspiration, and the lagoon opening condition. The dike in the east basin has a height of 7.5 ft. NGVD, and the spillways have a crest elevation of 5.5 ft. NGVD. When the culverts in the dike are closed, water must reach an elevation of 5.5 ft. above NGVD before water is transferred to the central basin. If the culverts are open, the water level can be drawn down to 1.5 ft. NGVD (Novick and Lauppe 1982).

Field observations of groundwater elevations in the east basin during 1975 showed that the groundwater table was within 3-4 feet of the surface. The depth to the groundwater surface increased toward the valley sides and in the tributary canyons. This implies that under normal hydrologic conditions, the groundwater reserves are unlikely to contribute to the surface water discharge. There will be seepage of water through the embankment of the Pacific Coast Highway and through the barrier beach at the inlet channel, resulting in a net loss of volume when the lagoon elevation is higher than the sea level.

Estimates for monthly inflows, evaporation, and precipitation are summarized in Table 3. These figures can be used to develop a water budget for San Elijo Lagoon (Table 4).

Calculations assume that the lagoon closes on January 1 following a breach, and the initial lagoon elevation is 0.0 ft. NGVD. If the lagoon is assumed to breach at an elevation of 5.5 ft. NGVD, the lagoon can be expected to breach once or twice a year on average. This preliminary water balance model also demonstrates that the lagoon elevation remains higher than desirable for health of the biota for several weeks before breaching naturally (unless there is significant rain inflow). This prediction is verified by field observations and demonstrates why the lagoon must be breached artificially at times to expose habitat for bird life, prevent prolonged

TABLE 2

SUMMARY OF DISCHARGES
ESCONDIDO CREEK AT INTERSTATE HIGHWAY 5

(Source: FEMA Flood Insurance Study,
Unincorporated Areas of San Diego County, Vol. I)

Return Period (Years)	Peak Flow (cfs)*
10	3,400
50	15,500
100	22,000
500	41,000

TABLE 3

ESTIMATED INFLOWS AND MONTHLY PRECIPITATION IN SAN ELIJO LAGOON

(Source: San Elijo Lagoon East Basin Water Management Plan, Smith/Williams, 1976)

Month	Average Year[1] (Inches)	Dry Year[2] (Inches)	Mean Monthly Flow (ac-ft)
January	2.14	1.46	462
February	2.07	1.41	529
March	1.82	1.24	404
April	1.00	0.68	383
May	0.35	0.24	88
June	0.08	0.06	21
July	0.02	0.02	3
August	0.07	0.05	2
September	0.15	0.10	2
October	0.50	0.34	14
November	1.19	0.81	51
December	2.28	1.55	351
TOTAL:	11.67	7.96	2,310

[1]Average between 1928 and 1973

[2]Assumes 20% chance of rainfall being less

TABLE 4

WATER BUDGET FOR SAN ELIJO LAGOON (CENTRAL AND WEST BASINS)

	Initial Conditions			Monthly Flow						Final Conditions		
	Elevation (ft.)	WS Area (ac.)	Volume (ac-ft)	Precipitation (in)	Precipitation (ac-ft)	Evaporation (in)	Evaporation (ac-ft)	Inflow[3] (ac-ft)	Seepage[4] Loss (ac-ft)	Volume (ac-ft)	Elevation (ft)	WS Area (ac)
Jan.	0.0	12	15	2.14	98	3.12 (2.56)	67	462 (449)	20	475	4	210
Feb.	4.3	210	509	2.07	95	3.60 (3.07)	153	529 (509)	25	BR	EA	CH
Mar.	0.0	12	15	1.82	83	6.24 (4.25)	52	404 (347)	20	373	3.6	185
Apr.	3.6	185	373	1.00	46	6.72 (5.24)	104	383 (555)	15	BR	EA	CH
May	0.0	12	15	0.35	16	8.64 (5.98)	28	88 (76)	5	74	1.5	65
Jun.	1.5	65	74	0.08	4	8.64 (6.57)	45	21 (9)	4	38	0.8	20
Jul.	0.8	20	29	0.02	1	9.35 (7.72)	15	3 (0)	0	15	0.0	12
Aug.	0.0	12	15	0.07	3	9.36 (7.40)	9	2 (0)	0	9	-0.4	9
Sep.	-0.4	9	9	0.15	8	6.72 (5.90)	5	2 (0)	0	12	-0.2	10
Oct.	-0.2	10	12	0.50	23	6.24 (4.41)	7	14 (0)	0	28	1.0	19
Nov.	1.0	19	28	1.19	55	4.56 (3.23)	15	51 (0)	3	65	1.6	68
Dec.	1.6	68	65	2.28	105	3.84 (2.52)	36	351 (145)	15	264	3.1	170

inundation of vegetation, eliminate extended exposure to fresh water, or for vector control purposes.

2.2.4 Salinity Distributions

In an estuary system, problems can arise from prolonged periods of salinity extremes. Fresh water has a salinity of 0 parts per thousand (ppt) and seawater has a salinity of 33 ppt. Biological damage to an estuary can occur below 10 ppt (hyposaline) or above 50 ppt (hypersaline).

San Elijo has experienced increasing year-round run-off from Escondido Creek, and from the continuing urbanization of the lagoon margins. Intrusion of freshwater plants into salt marsh habitat is particularly encouraged by discharge from storm drains. When this water collects in the lagoon due to blockage of the mouth, it dilutes the existing salinity. This decreased salinity has encouraged the establishment and growth of freshwater vegetation in areas formerly entirely covered by salt marsh vegetation. The proliferation of cattails and tules in former salt marsh immediately west of Interstate 5 threaten to impair water circulation as their rhizomes anchor and catch sediment, building islands in the already narrow channel. The reduced salinity also encourages the proliferation of insect species considered to be pests to society, namely mosquitoes, gnats, and midges. Hyposalinity has been a factor in determining when to artificially breach the lagoon mouth in recent years.

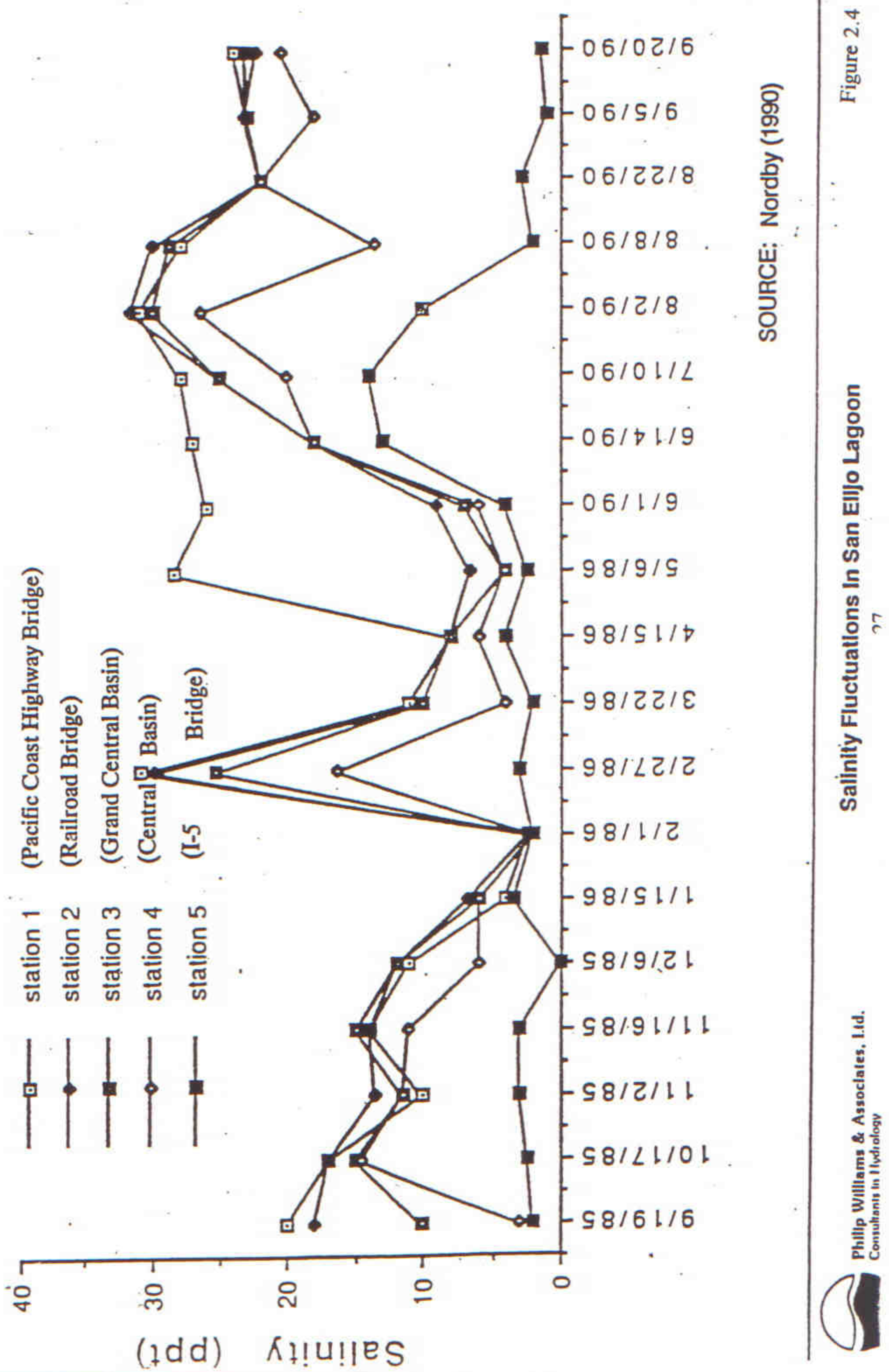
The Pacific Estuarine Research Laboratory (PERL) of San Diego State University has been collecting salinity data at five monitoring stations in San Elijo Lagoon since September 1989 (Nordby 1989-1990, Boland 1990-1993). These data have been collected at approximately bi-monthly intervals. Salinities were also measured by Philip Williams & Associates at five stations during the synoptic tide measurements in February 1991, and the Department of Parks and Recreation has taken spot salinity measurements during significant hydrologic changes in the lagoon. The PWA data are summarized in the Hydrology Appendix.

The salinity levels in the lagoon fluctuate from 2 to 36 ppt throughout the year, depending upon the freshwater inflows and lagoon opening condition (Figure 2.4). In general, PERL found salinity relatively high during October, November, and December, lower during January, February, and April, and rising again in May.

The wide fluctuations in salinity in the lagoon create a stressful environment for marine and freshwater biota (Nordby 1990). The severe shifts make it impossible for the establishment of a permanent invertebrate prey base (crabs, worms, etc.), resulting in a less varied diet for the wildlife dependent upon this base.

In addition, there is a general decrease in salinity with increased distance from the mouth and a corresponding decrease in temperature. However, PERL found that during the four years of salinity monitoring, the anticipated gradient from seawater in the west basin to near fresh water

Exhibit 3: San Elijo Lagoon Area Enhancement Plan



Salinity Fluctuations In San Elijo Lagoon

Figure 2.4

in the east basin never occurred. Also, the overall salinities in the lagoon were relatively low in comparison with other lagoons in the region. The average bottom salinity for San Elijo Lagoon in 1991-1992 was 13 ppt and in 1992-1993 was 11 ppt. The average bottom salinity for nearby Los Peñasquitos Lagoon was 26 ppt in 1991-1992 and 24 in 1992-1993. This two-fold salinity difference between the two lagoons is apparent in the different biology: Los Peñasquitos is a salt marsh whereas San Elijo Lagoon is a brackish marsh.

2.2.5 Water Quality

Potential water quality problems in San Elijo Lagoon include excessive nutrient levels, excessive sedimentation, increased fresh water, chemicals such as petroleum products and pesticides, heavy metals, and high bacteria levels.

The Regional Water Quality Control Plan, Hydrology Appendix (1978) summarized the problem of water quality in San Elijo Lagoon as accumulated nutrients from the discharge of secondary treated sewage effluent or from surface runoff. In 1979, the levels of heavy metal concentration were well below permissible standards.

Watkins (1987) monitored the lagoon in 1986 and 1987 to determine the effect of rainfall and tidal flushing on biological oxygen demand (BOD), fecal coliform, fecal streptococci, pH, turbidity, salinity, dissolved oxygen, and nitrate-nitrogen levels. The report concluded that the water quality in the lagoon was improved during this period compared with previous years, and coliform and nitrate-nitrogen levels were within EPA guidelines. Watkins also concluded that water quality in the lagoon was improved by tidal flushing.

In the 1990 Water Quality Assessment, the San Diego Regional Water Quality Control Board identified 150 acres of the 530-acre San Elijo Lagoon as having impaired water quality; the board determined that the lagoon's low rating was due to eutrophication and accelerated sedimentation.

In 1993, the Soil Conservation Service prepared the Escondido Creek Hydrologic Area: Project Report for the San Diego Regional Water Quality Control Board to identify causes and methods to minimize nonpoint source pollution loading in the San Elijo Lagoon watershed. The report summarized the following problems associated with each nonpoint pollution constituent:

Excess Nutrients
· Alters biodiversity, impacts coastal fish populations.
· Increases algae and phytoplankton growth which leads to eutrophication.

Sediment
· Contains toxics or nutrients.
· Affects the numbers and diversity of species.

· Increased sediment deposition reduces the tidal prism.
· The loss in suitable habitat reduces coastal fish species.
· Loss of forage and habitat for threatened and endangered species.

Excess Freshwater
· Decreases the normal salinity gradient.
· Loss of microhabitats and a decline in species diversity.
· Loss of salt marsh, salt water, and salt panne habitat.
· Change in fish species from salt water to fresh water.
· Less saline water increases mosquito, gnat, and midge populations.
· Impacts threatened and endangered species.

Bacteria
· Potential human health risks for surfers, beachgoers, and park users.

(For a more detailed discussion of these constituents and their effect on San Elijo Lagoon biota, see Soil Conservation Service 1993 and Gersberg 1995.)

The SCS identified several causes for the water quality problems in San Elijo Lagoon. High bacteria levels in the lagoon may be caused by sewage spills, storm drain runoff that is inherently contaminated, the poor sanitary practices around buildings along the commercial section near the mouth of the lagoon, and agricultural runoff from farms and pastures. High nutrient levels are caused by all types of fertilizers for residential and agricultural purposes, nutrient cycling in the lagoon itself, and all types of animal wastes (agricultural, domestic, and wildlife such as waterfowl). Nutrient and coliform contributions by transients, migrant camps, and joggers are minor but ongoing and could cause health risks if infected individuals pollute the waterway.

PERL has monitored the annual changes in dissolved oxygen since 1989, noting the highly variable conditions that characterize San Elijo Lagoon. Nordby (1990) found that, in general, the west and central basins had higher dissolved oxygen than did the fresher Eastern basin, probably due to greater aeration by wind action in these more exposed and shallower parts of the lagoon. Dissolved oxygen decreased following the September, 1989 rainfall and runoff, and stabilized during the winter and spring except beneath the Interstate 5 overpass. During the summer, oxygen levels were extremely low at the mouth of the lagoon following dredging, possibly due to the accumulation and decomposition of kelp that had collected in the hole created by the dredging.

PERL found that the fluctuations in water salinity and, to a lesser extent, dissolved oxygen at San Elijo Lagoon dictates the biology of the lagoon. Because of prolonged low oxygen levels, San Elijo Lagoon lacks the benthic infauna normally associated with southern California estuaries and lagoons. The richness (number of species) and abundance of fish species were found to be lacking relative to tidally flushed systems. It is likely that some bottom-dwelling organisms that could not escape low oxygen levels are killed (i.e., infaunal invertebrates), while the more mobile animals (fish and epifaunal invertebrates) are able to move to shallower water where the oxygen levels are higher.

In November of 1992, the County Department of Parks and Recreation began a water quality study of San Elijo Lagoon with funding and technical assistance from the EPA. This was a three-year study and the results are now available.

2.3. BIOLOGICAL RESOURCES

Biologists from the County of San Diego Department of Parks and Recreation (Patton and Welker, 1993) compiled the available data and conducted field studies of the area for the biological element of the Enhancement Plan. The Pacific Estuarine Research Laboratory (Nordby 1989-1990, Boland 1991-1994) conducted biological and water quality monitoring (salinity measurements and adult and juvenile fish and benthic invertebrate sampling). Although the main focus of this data is on the ecological reserve, the upland and watershed areas are also considered as they affect the viability of the reserve.

2.3.1 Plant and Animal Communities

More than 300 species of plants have been recorded within the San Elijo Lagoon Ecological Reserve. Eighteen of these species are on the California Native Plant Society (CNPS) list as sensitive, rare, or threatened species. A list of plants identified in the area is included in the Biology Appendix (see also Section 2.3.3.2 for a list of sensitive species).

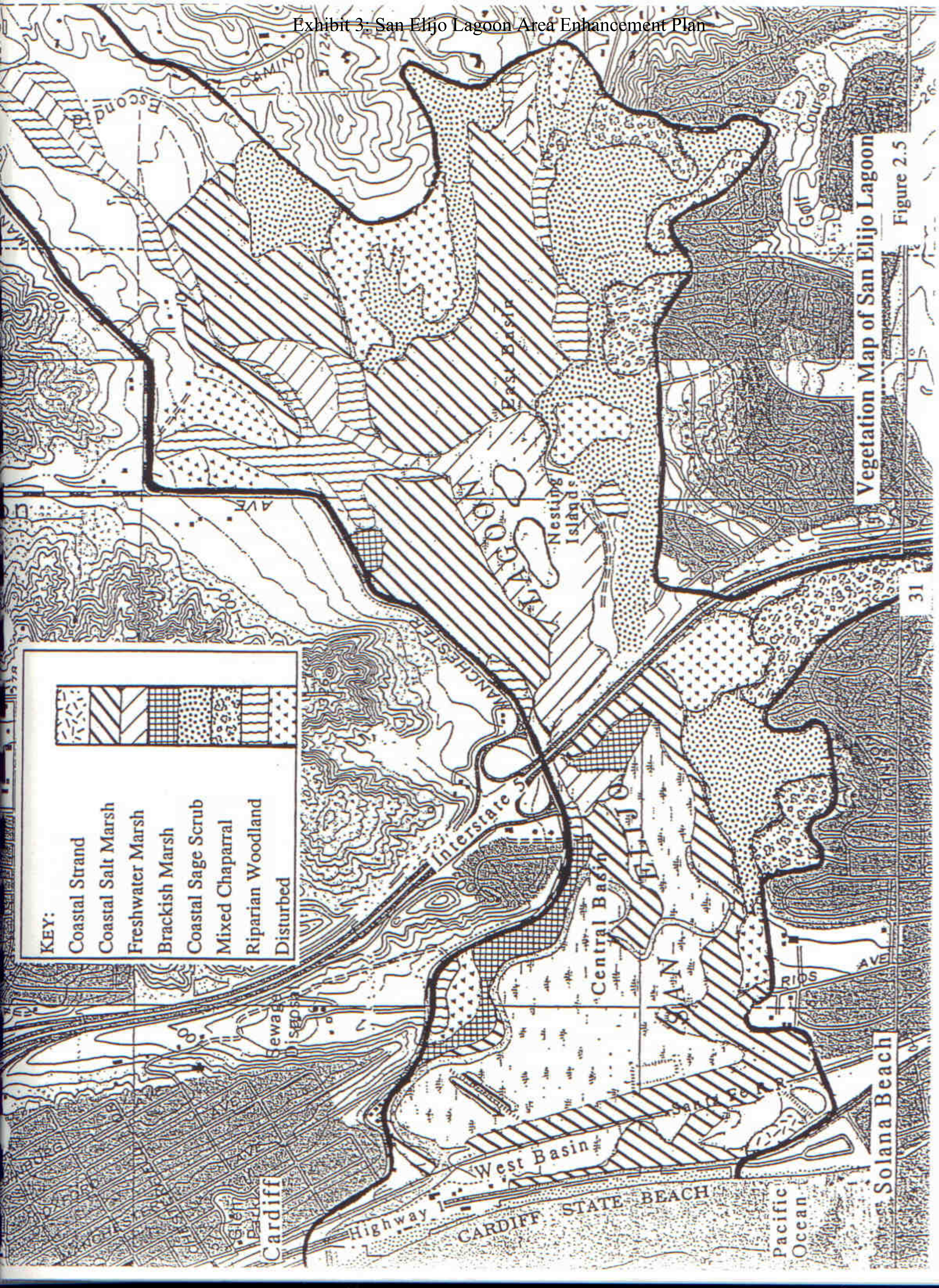
The San Elijo Lagoon Area contains six plant communities: coastal strand, coastal salt marsh, freshwater marsh, riparian woodland, chaparral, and coastal sage scrub (Beauchamp 1986 and Munz 1974; Figure 2.5).

2.3.1.1 Coastal Strand

The coastal strand element in the San Elijo Lagoon Area is represented by a small area of remnant dune in the west basin. Added to the Ecological Reserve in 1989, this area has been considerably degraded through off-road vehicle activity and invasion by exotic plants. Additionally, this area is isolated from the beach by Highway 101 and is not replenished with fresh wind-driven sand. Typical native strand plants observed here include beach sand verbena (*Abronia umbellata*), beach evening primrose (*Camissonia cheiranthifolia* ssp. *suffruticosa*), desert arrow-weed (*Tessaria sericea*), and various introduced species including sea rocket (*Cakile maritima*) and Hottentot-fig (*Carpobrotus edulis*).

Recent efforts at removal of non-native ice plant have resulted in an increase in native plant species. Continued exotic plant removal and seasonal restriction of human access will make the

Exhibit 3: San Elijo Lagoon Area Enhancement Plan



Vegetation Map of San Elijo Lagoon

Figure 2.5

site suitable for nesting of endangered California least terns and threatened western snowy plovers. The globose dune beetle, a federal candidate for listing as an endangered species, has not been observed at this time, but this habitat could support the insect. The silvery legless lizard was observed here in 1995.

2.3.1.2 Coastal Salt Marsh

In recent years, the tidal connection with the sea has been highly variable at best. This is not conducive to a stable salt marsh community, and it excludes "low marsh" plant components such as cordgrass (*Spartina foliosa*) that do not tolerate prolonged inundation.

Vegetation in this community is low in stature, usually succulent and salt-tolerant (halophytic). Indicator species found include several species of pickleweed (Salicornia sp.), alkali heath (*Frankenia salina*), saltgrass (*Distichlis spicata* var. *spicata*), shoregrass (*Monanthochloe littoralis*), and southwestern spiny rush (*Juncus acutus* var. *sphaerocarpus*).

Several gradients of salt marsh communities occur within the reserve, usually in relation to the degree of salinity. Under the broad title of "salt marsh" are roughly four distinctive forms of salt marsh habitat, each having different morphological characteristics. They are:

1) Frankenia-dominated vegetation, generally eastward of any possible inundation by the tides, but subject to storm flooding. Frankenia is found in extensive monotypic stands, forming dense thickets up to 75 cm. tall.

2) Pickleweed-dominated, low-lying areas east of the tidal inundation, generally in saline, anaerobic clay soil. Pickleweed (*Salicornia virginica*) becomes a dominant plant with dense growth to 50 cm. tall and excludes other species.

3) Salt panne marsh at the eastern end of the reserve, which is inundated by storm waters, mainly backed up by the flood control dike east of Interstate 5. These areas become hypersaline during the summer and, with reflected light and heat from the white, salt-covered surfaces of the soil, provide inhospitable growing conditions. Coulter's saltmarsh-daisy (*Lasthenia glabrata* ssp. *coulteri*) is found here.

4) Typical tidally influenced (albeit sporadic) salt marsh, dominated by salicornia and distichlis. In this last salt marsh category, increasing fresh water is evidenced by the ongoing invasion of freshwater plant species such as cattails (Typha sp.), sedges or tules (Scirpus sp.), and rushes (Juncus sp.) into areas formerly supporting typical halophytes.

Salt marsh vegetation is used for nesting and foraging by the state endangered Belding's savannah sparrow and by song sparrow and marsh wren. Mallards and gadwall nest regularly in fringe areas. When submerged with winter rains, vegetation east of Interstate 5 provides forage for thousands of wintering waterfowl.

The open salt pannes in the salt marsh at the east end of the reserve are potential habitat for several species of endangered salt marsh tiger beetles. In some areas of the lagoon, particularly in the west basin and along the south shore of the central basin, monotypic stands of salt grass occur, providing ample larval feeding habitat for the saltmarsh skipper. This butterfly is a federal candidate for endangered species status and is found in the reserve and other coastal habitats supporting salt grass. The state and federally endangered California least tern and federally threatened western snowy plover nest on the open salt panne substrate, as do black-necked stilts, American avocets, killdeer, and spotted sandpipers. With moderate winter water levels, salt panne areas are inundated, resulting in shallows and mudflats heavily used by shorebirds for feeding and roosting.

2.3.1.3 Freshwater Marsh

Historically, San Elijo received fresh water seasonally during the winter via Escondido and La Orilla creeks, with only minor flow during the summer months. This would have supported a freshwater marsh component limited to upstream areas beyond tidal influences.

As a result of increasing urban runoff and flow during the summer, the freshwater marsh community appears to be currently displacing vegetation in areas recently occupied by the salt marsh community. This shift was accelerated when the lagoon received sewage effluent, which continued until the 1970s. This influx of more or less fresh, nutrient-laden water, combined with the restricted exchange with the ocean, favors the increase of cattails and tules. Formerly confined to the eastern end of the reserve, cattails and tules now grow well into the central basin. Freshwater marsh vegetation can become established in salt and brackish marsh situations during periods of freshwater inundation and prove to be extremely resistant to the effects of salt water when the fresh water is withdrawn (Beare 1987). At San Elijo, the presence of tules and cattails in the east basin serve as an organic sediment trap, slowing siltation of the central basin. This dense growth also removes some nutrients and pollutants, which could trigger the episodic algal blooms leading to eutrophication.

The freshwater marsh habitat is intensively used by wildlife such as raccoons. An abundant population of crayfish (Cambarus sp.) provides a substantial prey base, supplemented by eggs of nesting birds, reptiles and amphibians, fish, small mammals, and vegetation. At San Elijo Lagoon and Escondido Creek this habitat has sustained a small population of the federally endangered light-footed clapper rail. Numerous other avian species reside and nest in the freshwater marsh. Others rely on it during migration and winter.

2.3.1.4 Riparian

Riparian woodland is classified by Munz as an element of the freshwater marsh community. Of great importance historically, this "community" has been greatly reduced statewide. San Elijo Lagoon Ecological Reserve itself has relatively few pockets of riparian species (mainly Salix), and except for a few individuals, these willows are of recent growth (30 years or less). Although individual sycamores (*Platanus racemosa*), cottonwoods (*Populus fremontii*), and willows (Salix sp.) of relatively old age may be found on the La Orilla Creek and Escondido Creek floodplains, none occur naturally within the reserve.

Old growth riparian woodland has traditionally supplied prime nesting sites for a variety of bird species and important foraging habitat for migrant songbirds. In addition, large eucalyptus trees growing in riparian areas, although an exotic species, provide significant nesting and roosting sites. Several bird species regularly nest in willow scrub within the reserve. The habitat is also the site of woodrat middens.

2.3.1.5 Chaparral

This plant community covers most of the uplands on the southern side of the reserve, where species indicative of both coastal sage scrub and chaparral communities intermingle, reflecting the diverse nature of the area. At San Elijo, the chaparral community is least disturbed on the bluffs immediately west of Interstate 5. This area supports a heavy concentration of chamise (*Adenostoma fasciculata*). Typical leathery-leafed shrubs include mission manzanita (*Xylococcus bicolor*), Del Mar manzanita (*Arctostaphylos glandulosa* ssp. *crassifolia*), and summer holly (*Comarostaphylis diversifolia*). Areas east of Interstate 5 also support wart-stemmed ceanothus (*Ceanothus verrucosus*), holly-leafed cherry (*Prunus ilicifolia*), and San Diego mountain mahogany (*Cercocarpus minutiflorus*). Chaparral is most developed on north and east facing slopes where soil moisture supports its higher water requirements.

2.3.1.6 Coastal Sage Scrub

The gentle slopes and flats of marine terraces and alluvial fans, mainly on the south and east sides of the reserve, are typified by classic coastal sage scrub vegetation: coastal sagebrush (*Artemesia californica*), California buckwheat (*Eriogonum fasciculatum*), both black and white sages (*Salvia mellifera* and *S. apiana*), and coyote brush (*Baccharis pililaris* ssp. *consanguinea*). Represented in a reduced area west of Interstate 5, this community is more abundant east of the freeway where the arid slopes between chaparral and the lagoon are more gentle. Coastal sagebrush appears to be the dominant plant, while coyote brush readily colonizes disturbed areas, being especially dominant on fans of sand deposits and old burn scars.

This plant community is undergoing increasing pressure in southern California as rapid development of the coastal plain continues. Numerous species are considered to be seriously threatened by the destruction of habitat.

Few animal species are found exclusively in one or the other of the chaparral or sage scrub habitats. This is the richest habitat in terms of abundance and diversity of mammals and reptiles. Reptiles and insectivorous birds exploit the insect populations and the plants for food or shelter.

Airborne adult stages of aquatic larval species such as Chironamid midges may be windblown to concentrate in large numbers above and in sage scrub vegetation. Such a prey base is a likely reason for denser coastal populations of federally threatened California gnatcatchers when compared to inland populations.

A large guild of resident seed-eating birds occupies the sage scrub/chaparral. Large numbers of migrant warblers exploit the insects in spring and fall, and wintering sparrows are attracted by the seeds.

Predatory reptiles, birds, and mammals rely on the abundant rodent and rabbit prey of the open sage scrub areas. Coyotes, bobcats, foxes, weasels, raccoons, snakes, and large numbers of migrating and wintering hawks hunt in the chaparral/sage scrub. The woodier chaparral provides cover for the larger mammals as well as nest materials for woodrats, Bewick's wrens, jays, and thrashers. Sandstone bluffs within upland areas provide nesting sites for rough-winged swallows, black phoebes, ravens, and owls.

2.3.1.7 Aquatic

While not a vegetation-based community, aquatic areas constitute a significant part of the San Elijo Ecological Reserve. Due to the fluctuating conditions of saline and fresh water, the aquatic vegetation assembly is predominantly algae. The vascular flowering plants, beakfruit sea-tassle (*Ruppia maritima*) and *Najas marina,* are found in the western end of the central basin.

The aquatic community includes several species of fish and invertebrates. Abundance and diversity of both groups drop when the lagoon is closed to the ocean, as low oxygen and salinity limit survival to hardy, opportunistic species and short-lived freshwater insects. Abundance and diversity increase greatly when the lagoon is open to the ocean, allowing movement and establishment of marine species.

Adjacent to open water are salt panne, mudflats, and marsh vegetation. Each component varies in size and nature depending on seasonal water levels. These are important to birds attracted by the aquatic system. At times, terrestrial and aquatic habitats are difficult to separate, given a tidal influence. Migratory shorebirds, terns, gulls, and waterfowl rely on salt panne for resting areas.

Comparison of monthly pre-opening and post-opening lagoon bird counts indicates that when the lagoon level is less than 2.9 feet above MSL (mean sea level), waterbird numbers and species diversity increase by 30 to 60 percent because of increased availability of foraging habitat. The lower water level increases access to food sources, whether submerged vegetation, fish, or invertebrates. In recent times, the lagoon has usually been nontidal. Shallows and mudflat areas adjacent to marsh and open water replace important intertidal foraging areas for shorebirds. At higher water levels, accessibility to food is diminished.

Open water is important to bird species relying on aquatic food items. It also provides protection as a physical deterrent to mammalian predators and human disturbances. Benthic substrate, slope, and bottom elevation variability allow plant, invertebrate, and fish diversity. At depths typical of winter (greater than 3.2 feet above MSL), the majority of the lagoon basins are flooded, making resources in most of the central basin available only to diving ducks. Dabbling ducks and large waders must use the east basin, whose eastern portions are open to smaller shorebirds if the level is 4.0 feet above MSL or lower.

Tens of thousands of shorebirds migrate through Southern California and utilize San Elijo Lagoon for foraging and roosting from late summer to spring. The highest numbers occur in late summer and fall as the birds move south. Waterfowl also migrate through in spring and fall by the tens of thousands and many remain to overwinter in the area. Wintering California gulls also rely on the open water each evening, flying in by the hundreds from shoreline and landfill foraging areas. Hundreds of elegant terns roost in the central basin, with smaller numbers of other terns foraging and roosting. Herons and egrets exploit the fish of the lagoon in medium to shallow depths year round.

2.3.1.8 Invasive Exotics

As in most lands subject to human activity, the San Elijo Lagoon Ecological Reserve has its share of exotic plants. Some of these imports made their appearance with the early settlers, or during the land grant period when large tracts were burned off to stimulate grass for grazing herds. Many exotic annual grasses and forbs would have become firmly established at this time, as frequent burns have been demonstrated to convert brushland to grassland and to favor rapid-growing, exotic annual grass species over the slower-growing native bunch grass species (O'Leary 1989). Recently, most escapees have been the offspring of plants imported for landscaping, most notably pampas grass (*Cortaderia atacamensis*), iceplant (*Carpobrotus* sp.), and eucalyptus species.

Whatever the source, many exotics become a perceived problem as they displace native plant species utilized by native wildlife. Many exotic species have little or no habitat value to native wildlife and often preclude native plant species from germinating. The continued spread of these exotics threatens the integrity of several habitats. Understory in riparian areas may be completely overpowered by exotics, reducing endangered least Bell's vireo habitat. Habitat of the threatened California gnatcatcher is also affected. Invasion by trees or tall shrubs such as tamarisk, myoporum, eucalyptus, acacia, castor bean, and Brazilian pepper in or adjacent to salt marsh, salt panne, or open water provides perch sites for raptors and cover for mammalian predators of endangered species. Likewise, invasion of such habitats by carderia, iceplant, pampas grass, or giant reed directly eliminates nest sites.

Eucalyptus stands upstream from the reserve provide nest sites for great blue herons and great egrets. Red-tailed and red-shouldered hawks also nest in eucalyptus trees adjacent to the reserve. However, these nonnative trees are used by only a limited number of species. Replacement by appropriate native species such as cottonwood, sycamore, oak, and Torrey pine would enhance the overall community by providing habitat for a greater number and diversity of species.

2.3.2 WILDLIFE

Due to the moderate climate, varied topography, and diversity of both aquatic and terrestrial ecotones, the San Elijo Lagoon area supports a considerable variety of animal species. The Biology Appendix lists wildlife species, sensitivity status of those species recorded, and possibly occurring vertebrates.

2.3.2.1 Invertebrates

There is a lack of comprehensive data on invertebrate species in the San Elijo Lagoon Ecological Reserve. Eighty-three invertebrate species have been recorded in casual observation or highly localized and specialized sampling (Biology Appendix). One insect species threatened with extinction, the wandering skipper, has been documented in the reserve. This butterfly species requires salt grass as a primary larval foodplant. The lagoon area has suitable habitat for other endangered insect species, including several species of tiger beetle and the globose dune beetle, although these species have not been recorded in the reserve.

PERL found that the benthic community of the lagoon illustrated well the impact of fluctuating water quality on aquatic organisms. The benthos of San Elijo Lagoon is often dominated by larval stages of insects with some opportunistic polychaetes, unlike many other Southern California lagoons that are dominated by bivalve mollusks and polychaete worms. Invertebrates are more common in summer and rare during spring and winter. During primarily freshwater periods when the lagoon is closed to the ocean, the invertebrate community is dominated by Chironomid midge larvae. Chironomids are characteristic of shallow freshwater systems with heavy aquatic plant growth. Boland has shown that increased salinities in the lagoon after the mouth is opened greatly reduces their population and they are replaced by a diversity of marine species (Boland 1992).

2.3.2.2 Fish

Based on the hypothesis that fish species and diversity in local lagoons is intimately associated with water quality, particularly salinity and dissolved oxygen, PERL conducted sampling of adult and juvenile fish in the lagoon (Biological Monitoring of San Elijo Lagoon, Chris Nordby 1989-1990 and John Boland, 1991-1993). Nordby found that the species diversity and density reflect the fluctuations in water quality found in the lagoon.

Over the 1989-1990 sampling period, fish representing seven species from five families were collected. Four species constituted 99% of the total: mosquitofish (*Gambusia affinis*), an introduced species, which made up 42% of the total; followed by longjaw mudsucker (*Gillichthys mirabilis*); topsmelt (*Atherinops* sp.); and arrow goby (*Clevelandia ios*). The dominance of mosquitofish is further evidence of the influence of freshwater inflows on the aquatic organisms of the lagoon. While this species is present in nearly every southern California lagoon and estuary, it is rare in tidally flushed systems such as the Tijuana Estuary. Other species at San Elijo Lagoon were euryhaline species, which are tolerant of a wide range of salinity conditions. Some of these species can withstand repeated rapid shifts from fresh or nearly fresh water to full-strength seawater (Nordby 1990).

During the 1991-1992 sampling period, 12 species of fish were trapped in the summer, mostly in the western part of the lagoon where the water was more saline. New fish species included anchovies and California halibut. During winter of this period, only one species, the longjaw mudsucker, was caught. This period was characterized by extreme salinity fluctuations.

The 1992-1993 summer sampling period yielded a total of 10 fish species, including California halibut. Topsmelt was the most abundant species collected. Again, most of the individuals were caught in the western end, where the water is most saline. Numbers declined dramatically in the winter to four species, probably because of a strong freshwater flow during January that washed many fish out of the lagoon.

The east basin flood control dike effectively separates a persistent freshwater location to the east from highly variable conditions to the west. Typical freshwater species of catfish, bluegill, and small numbers of bass inhabit the channels of the east basin, along with nonnative carp and mosquito fish and more estuarine mullet. Periodic isolation between basins (created by the dike) and between lagoon and ocean (caused by closure of the lagoon mouth) influences species distribution by limiting access and spawning of many marine and estuarine animals. Conversely, species distribution is influenced by flood events, such as when water levels over-top the dike and allow movement between basins, and when the lagoon mouth berm is breached. This latter event results in net outflow of a large volume of water and strong currents, purging individuals from the lagoon entrance channel. Later tidal exchange allows movement of species between the ocean and lagoon.

During periods of tidal exchange between the lagoon and ocean, species diversity and abundance are high, with many marine and estuarine fish and invertebrates. Following closure of the lagoon, diversity and abundance remain high only as long as salinity and dissolved oxygen remain high. Decreases in either result in death for some species and persistence of those species tolerant of a wide range of water quality. Because aquatic plants (particularly algae and phytoplankton) influence oxygen levels and urban runoff decreases salinity, optimal conditions rarely endure for any length of time once the lagoon is closed to the ocean.

2.3.2.3 Amphibians and Reptiles

Though no structured sampling has occurred, sixteen native amphibian and reptile species and three naturalized species have been documented by County staff at San Elijo (see Biology Appendix). Up to twelve additional species are potentially present.

Most reptile species are fairly widespread throughout the uplands and wetland transition area of the reserve, and in salt marsh and riparian areas during periods of low water level. The western fence lizard is the most abundant and ubiquitous. Orange-throated whiptails are widely spread throughout the coastal sage scrub. The two-striped garter snake has been documented in both central and east basins, and gopher snakes, kingsnakes, and Southern Pacific rattlesnakes are residents in the uplands.

2.3.2.4 Birds

Bird use at San Elijo has been one of the most studied elements of the reserve and, because of avian abundance, variety, and high visibility, the component most noticed by the public. More than 298 species have been recorded at San Elijo Lagoon (see Biology Appendix), and several more offshore from Cardiff State Beach. Numbers of individuals range into the tens of thousands when considering migratory shorebirds and waterfowl, into the thousands for coots, gulls, swifts, and swallows, and into the hundreds for pelicans and cormorants, herons and egrets, terns, warblers, sparrows, and blackbirds. Such numbers and diversity are attributable to geographic/physical factors of location, variety of habitats and ecotones, and variety and abundance of food items.

San Elijo and San Diego County's median latitude provides an accommodating location for large numbers and wide diversity of bird species. They fall into four groups: 1) residents, 2) migrants, 3) wintering species that breed elsewhere, and 4) breeding species that winter elsewhere. The coastal location, maritime influence on weather, varied topography and soils, and estuarine influence of both fresh and salt waters create a diverse assemblage of plant types and habitats. The outcome of such diversity is a wide variety and abundance of food items.

More than 77 bird species of concern have been recorded at San Elijo, including 16 of the 63 species that regularly breed around the lagoon. Six federally endangered species have been documented in the reserve: brown pelicans, light-footed clapper rails, California least terns, peregrine falcons, bald eagles, and least Bell's vireos. Federally threatened snowy plovers, California gnatcatchers, and state endangered Belding's savannah sparrows are also present. Species that are federal candidates for listing as endangered include white-faced ibises, long-billed curlews, reddish egrets, and tricolored blackbirds. (Refer to Section 2.3.3.3.3: Sensitive Birds.)

2.3.2.5 Mammals

County staff has documented twenty-six native mammal species and three naturalized species at San Elijo. These include eleven rodents, all three rabbit species occurring in the county, coyote, grey fox, raccoon, bobcat, mountain lion, sea lion, and mule deer. An additional fifteen species are potentially present. With the exception of bats, mountain lion, sea lion, and deer, all of these mammalian species are resident. The diversity of plant communities accounts for the reserve's diversity of small mammals. The larger resident mammals are somewhat opportunistic predators and undoubtedly rely not only on natural food sources but those available in adjacent urban areas such as household garbage and pet food. Reports from local homeowners of bobcat and fox sighting are common, and complaints of raccoons, skunks, and coyotes as pests have increased in recent years. The raccoon population has undoubtedly benefitted as well from the invasion of freshwater vegetation, especially in the east basin.

Deer have been observed periodically throughout the east basin and are believed to move along the riparian corridors of the creeks. Mountain lions have been reported annually each spring on the south side of the east basin and are believed also to rely on the riparian corridors of the creeks to migrate between the rich prey refuges of the lagoon and the undeveloped foothills to the northeast. The rural design of Rancho Santa Fe and its golf courses also allow movement from San Elijo to the San Dieguito River Valley and access to its resources.

No comprehensive surveys or mistnet sampling has been done at San Elijo to identify bat species or use, despite the rich prey base evidenced by diurnal insectivorous bird species. Eight of the twelve potentially occurring but unconfirmed mammal species are bats. Four of the species that are potentially present in the area are considered species of special concern by the State of California. Pallid, California leaf-nosed, and Townsend's long-eared bats may forage over the reserve and reside in small caves typical of the Torrey-Linda Vista sandstone formation interface.

2.3.3 Sensitive Biological Resources

2.3.3.1 Sensitive Communities

Increasing urban development in Southern California has significantly reduced natural areas. Many species that are resident or were formerly resident in coastal areas of San Diego County have been formally listed as endangered by governmental agencies because of loss or degradation of habitat. Many more species are considered sensitive by government, scientific, or conservation organizations. Recognition of this has resulted in efforts to identify natural communities, their physical requirements and characteristics, and residents that act as "early warning signs" for the health of the community as a whole. Many of these obligate resident species have been listed as endangered.

The California Department of Fish and Game, which classifies plant communities somewhat differently from Munz or Beauchamp, recognizes several of the natural communities occurring at San Elijo as sensitive "with highest inventory priorities." These include the communities of coastal strand; southern coastal bluff scrub; Diegan coastal sage scrub; southern coastal salt marsh; coastal brackish marsh and coastal freshwater marsh; and southern riparian scrub (California Department of Fish and Game 1987, Holland 1986). Each of these plant communities has been discussed previously (refer to sections 2.3.1 Plant and Animal Communities and 2.3.2 Wildlife) but aspects of the three dominant communities are summarized here:

2.3.3.1.1 Salt Marsh

San Elijo supports most of the common salt marsh species. However, due to the intermittent nature of tidal exchange, the composition of the salt marsh community is lacking several typical species, most notably California cordgrass (*Spartina foliosa*), dwarf glasswort (*Salicornia bigelovii*), and American saltwort (*Batis maritima*), all indicators of active and healthy tidal activity. In addition, the invertebrate community is not as diverse or abundant as would be expected in a more tidally influenced system.

Mudflats adjacent to salt marsh are significant foraging and roosting areas for shorebirds. Habitat availability related to water level appears to dictate not only abundance but species diversity, each changing as much as 60 percent depending on water depth and mudflat exposure.

2.3.3.1.2 Riparian

While the riparian community within the boundaries of the Reserve is not of great size or age, the riparian corridors of Escondido and La Orilla creeks are substantial when considered as a whole. Since periodic flooding and the presence of a high water table has limited real estate development in the lower floodplain, these wooded corridors provide a vital biological link for the exchange of individuals and their genetic material from areas around the reserve.

2.3.3.1.3 Coastal Sage Scrub

This plant community is rapidly shrinking because of the ongoing human development of the coastal plain of Southern California. The relatively narrow coastal strip under maritime influence continues to be extensively developed, with no current plans for substantial and coordinated preservation in the near future. Numerous sensitive plant, animal, and invertebrate species are considered to be at risk because of continued development pressure.

San Elijo hosts a high density of federally threatened California gnatcatchers. The federal candidate orange-throated whiptail and San Diego horned lizard are also frequently sighted throughout the sage scrub. Habitat is being enhanced by the closing of redundant trails, reduction of damaging human use of some steep and erodible areas, and revegetation efforts.

2.3.3.2 Sensitive Plant Species

Sensitive plant species are defined as those listed by the California Native Plant Society (CNPS) (Smith & Berg 1988), U.S. Fish and Wildlife Service, or California Department of Fish and Game (DFG). Listing by CNPS is recognized by DFG as an indication of sensitivity, and is generally used by biologists as a "candidate" species list. Table 5 is a list of naturally occurring sensitive plant species found within the boundaries of San Elijo Lagoon Ecological Reserve. Table 6 explains the CNPS RED code used in defining species status. The Torrey pine, although occurring within the reserve, is not listed, as the individuals found are young and are assumed to be progeny of local trees in landscaping situations, rather than a viable native population.

TABLE 5
SENSITIVE PLANT SPECIES OF THE SAN ELIJO LAGOON AREA

Adolphia californica
California Adolphia
CNPS List: 2, R-E-D Code: 1-2-1, State/Fed Status: none
Adolphia is a low, spiny shrub limited to coastal sage scrub and chaparral in San Diego County and Baja California.

Arctostaphylos glandulosa ssp. *crassifolia*
Del Mar Manzanita
CNPS list: 1B, R-E-D Code: 3-3-2, Fed Status: C1
An evergreen shrub of coastal chaparral, this species is threatened by development and agriculture on coastal bluffs and mesas.

Artemisia palmeri
San Diego Sagewort
CNPS List: 2, R-E-D Code: 2-2-1, State/Fed Status: None
San Diego sagewort is a rangy perennial found in coastal sage scrub communities in San Diego County and Baja California.

Ceanothus verrucosus
Wart-Stemmed Ceanothus
CNPS List: 2, R-E-D Code: 1-2-1, State/Fed Status: C2
This large, white-flowered shrub is found in coastal chaparral communities in San Diego County and Baja California.

Comarostaphylis diversifolia ssp. *diversifolia*
Summer Holly
CNPS List: 1B, R-E-D Code: 2-2-2, State/Fed Status: C2
This evergreen shrub is found in the coastal chaparral communities of San Diego and Orange counties and in Baja California.

Coreopsis maritima
Sea Dahlia
CNPS List: 2, R-E-D Code: 2-2-1, State/Fed Status: None
A deciduous perennial in the composite family, sea dahlia is found in coastal sage scrub in San Diego County and Baja California.

TABLE 5 (cont.)

Corethrogyne filaginifolia var. *incana*
San Diego Sand Aster
CNPS List: 1B, R-E-D Code: 2-2-2, State/Fed Status: None
A summer-blooming, lavender daisy, this coastal sage scrub member is found in San Diego County and Baja California.

Corethrogyne filaginifolia var. *linifolia*
Del Mar Mesa Sand Aster
CNPS List: 1B, R-E-D Code: 3-2-3, State/Fed Status: C2
This variety is found in coastal chaparral only in San Diego County.

Dichondra occidentalis
Western Dichondra
CNPS List: 4, R-E-D Code: 1-2-1, State/Fed Status: C3c
This low-growing, perennial plant is found in chaparral, coastal sage scrub, valley and foothill grassland, and cismontaine woodland over much of Southern California.

Ferocactus viridescens
San Diego Barrel Cactus
CNPS List: 2, R-E-D Code: 1-3-1, State/Fed Status: C2
A small barrel cactus threatened by development, collecting, and off-road vehicles, this plant is found in coastal sage scrub, valley and foothill grasslands, and chaparral in San Diego County and Baja California.

Harpagonella palmeri var. *palmeri*
Palmer's Grapplinghook
CNPS List: 2, R-E-D Code: 1-2-1, State/Fed Status: C2
A white-flowered annual of chaparral, coastal sage scrub, and valley and foothill grassland, this widely distributed plant is inconspicuous and easy to overlook.

Iva hayesiana
San Diego Marsh Elder
CNPS List: 2, R-E-D Code: 2-2-1, State/Fed Status: None
A low shrub of freshwater marsh and riparian areas in coastal sage scrub. Found in San Diego County and Baja California.

Juncus acutus var. *leopoldii*
Spiny Rush
CNPS List: 4, R-E-D Code: 1-2-1, State/Fed Status: None
A widely distributed perennial of coastal salt marshes, alkaline marshes, and coastal dunes, this plant is threatened by urbanization and off-road activities.

TABLE 5 (cont.)

Lasthenia glabrata ssp. *coulteri*
Coulter's Goldfields
CNPS List: 1B, R-E-D Code: 2-3-2 Fed Status: C2
A yellow-flowered annual found in coastal salt marshes and saline flats, this species is threatened by agriculture and urbanization.

Lotus nuttallianus
Nuttall's Lotus
CNPS List: 1B, R-E-D Code: 3-3-2, State/Fed Status: C2
A plant of coastal dunes and coastal sage scrub found in San Diego County and Baja California.

Nemacaulis denudata var. *denudata*
Coast Wooly-heads
CNPS List: 2, R-E-D Code: 2-2-1, State/Fed Status: none
An annual species confined to coastal dunes and sandy areas of Southern California and Baja California.

Quercus dumosa
Nuttall's Scrub Oak
CNPS List: 1B, R-E-D Code: 2-3-2, State/Fed Status: C2
This upland shrub is a typical component in coastal chaparral and sage scrub. It is threatened by development.

Selaginella cinerascens
Ashy Spike-moss
CNPS List: 4, R-E-D Code: 1-2-1, State/Fed Status: None
A ground-hugging species of Southern California and Baja California, limited to chaparral and coastal sage scrub.

TABLE 6

THE CALIFORNIA NATIVE PLANT SOCIETY (CNPS) LIST AND R-E-D CODE

List:

1	Presumed extinct in California
1B	Rare, threatened or endangered in California or elsewhere
2	Rare, threatened or endangered in California, but more common elsewhere
3	More information needed
4	Limited distribution, "watch list"

R-E-D Code:

R (Rarity):

1	Rare, but found in sufficient numbers and distributed widely enough that the potential for extinction is low at this time
2	Occurrence confined to several populations or to one extended population
3	Occurrence limited to one or a few highly restricted populations, or present in such small numbers that it is seldom reported

E (Endangerment):

1	Not endangered
2	Endangered in a portion of its range
3	Endangered throughout its range

D (Distribution):

1	More or less widespread outside California
2	Rare outside California
3	Endemic to California

STATE LISTED PLANTS:

CE = State listed, endangered
CR = State listed, rare
CT = State listed, threatened

FEDERALLY LISTED PLANTS:

FE = Federally listed, endangered
FT = Federally listed threatened
C1 = Enough data are on file to support the federal listing
C1* = Enough data are on file to support federal listing, but the plant is presumed extinct
C2 = Threat and/or distribution data are insufficient to support federal listing

TABLE 6 (cont.)

C2* = Threat and/or distribution data are insufficient to support federal listing; plant presumed extinct
C3a = Extinct
C3b = Taxonomically invalid
C3c = Too widespread and/or not threatened

TABLE 7

SENSITIVE ANIMAL SPECIES OF THE SAN ELIJO LAGOON AREA

REPTILES
(15 species, 7 sensitive)

Key:

F2	Federal candidate for endangered
CSC	California species of special concern
E	San Diego Herpetological Society (SDHS) endangered
T	SDHS threatened:

Phrynosoma coronatum blainvillii San Diego Horned Lizard	F2, CSC, E
Cnemidophorus hyperythrus beldingi Orange-throated Whiptail	F2, CSC, T
Cnemidophorus tigris multiscutatus Coastal Western Whiptail	F2, CSC
Eumeces skiltonianus interparietalis Coronado Skink	F2, CSC
Anniella pulchra pulchra Silvery Legless Lizard	CSC, T
Thamnophis hammondii hammondii Two-striped Garter Snake	F2, CSC, T
Diadophis punctatus similis San Diego Ringneck Snake	F2

MAMMALS
(26+ species, 3 sensitive)

Lepus californicus bennettii San Diego Black-tailed Jackrabbit	F2, CSC
Perognathus fallux fallux Northwestern San Diego Pocket Mouse	F2, CSC

TABLE 7 (cont.)

Onychomys torridus ramona Southern Grasshopper Mouse	F2, CSC

BIRDS (listed in decreasing order of sensitivity)
(296+ species, 104 uncommon migrants, 63+ nesting, 74 sensitive - 16 breed on site)

Key:
- N = nesting

Federal Status
- FE = endangered
- FT = threatened
- F2 = candidate for endangered
- FS = sensitive

California Status
- CE = endangered
- CT = threatened
- CCE = candidate for endangered
- CW = watch list
- CFP = fully protected
- CSC1 = species of special concern highest priority
- CSC2 = second priority
- CCS3 = third priority

Tate (National Audubon Society)
- TB = blue list
- TSC = special concern
- TLC = local concern

Everett (San Diego Audubon Society)
- ET = threatened
- ED = declining
- ES = sensitive

Unitt (San Diego Natural History Museum)
- UD = declining

Light-footed Clapper Rail		N	FE, CE, TSC, ET, UD
California Least Tern		N	FE, CE, ET, UD
Brown Pelican			FE, CE, ET
Peregrine Falcon	(winter)		FE, CE, ET
Least Bell's Vireo	(rare)		FE, CE, ET, UD
Wood Stork	(rare)		FE
Bald Eagle	(rare)		FE, CE, ED, UD
California Gnatcatcher		N	FT, CSC2, TLC, ED, UD
Western Snowy Plover		N	FT, CSC2, TSC, ED, UD
Belding's Savannah Sparrow		N	F2, CE, ED, UD

TABLE 7 (cont.)

Willow Flycatcher	(rare)		F2, CSC1, TSC, ED, UD
White-faced Ibis			F2, CSC1, ED
Reddish Egret	(rare)		F2, TSC
Fulvous Whistling-Duck	(rare)		F2, CSC1, TSC
Black Rail	(rare)		F2, CT, UD
Long-billed Curlew			F2, TSC
Elegant Tern			F2, CSC3
Black Tern			F2, TB
Ferruginous Hawk			F2, CSC, TSC
California Horned Lark			F2
Cactus Wren	(rare)		F2, ED, UD
Loggerhead Shrike		N	F2, TB
Rufous-crowned Sparrow			F2, UD
Large-billed Savannah Sparrow			F2
Tricolored Blackbird	(rare)		F2, ED, UD
Black-shouldered Kite		N	CFP
Golden Eagle	(rare)		CFP, CSC3
Purple Martin	(rare)		CCE, CSC2, TSC, ED
Common Loon	(rare)		CSC1, TLC
Western Grebe			CW, TSC, ES
Double-crested Cormorant			CSC2, TLC, ED
American White Pelican			CSC1, TLC
Least Bittern			CSC3, TB, ED, N, F2
Cooper's Hawk		N	CSC3, TB, ED
Sharp-shinned Hawk			CSC3, CW, TB
Northern Harrier			CSC2, TB, ED
Osprey			CSC2, TLC
Merlin	(rare)		CSC1, TSC
Prairie Falcon	(rare)		CSC3
California Gull			CSC3
Black Skimmer			CSC3
Gull-billed Tern	(rare)		CSC2
Burrowing Owl	(rare)		CSC2, TSC, ED
Long-eared Owl	(rare)		CSC2, ED
Short-eared Owl	(rare)		CSC2, TB, ED
Black Swift	(rare)		CSC3
Vermillion Flycatcher	(rare)		CSC1
Bank Swallow	(rare)		CSC2
Bendire's Thrasher	(rare)		CSC3
Virginia's Warbler			CSC2, TSC, ED, UD
Yellow-breasted Chat		N	CSC2, ED, UD
Summer Tanager	(rare)		CSC2
Great Blue Heron			CW, TLC, ES
Great Egret			CW

TABLE 7 (cont.)

Caspian Tern		CW
Black-crowned Night-Heron		TLC, ES
American Bittern		TB
Canvasback		TSC
Turkey Vulture		TLC
Red-shouldered Hawk		TB
Common Tern		TLC
Barn Owl		TSC
Hairy Woodpecker		TSC
Eastern Phoebe (rare)		TSC
Cliff Swallow	N	TLC
Bewick's Wren	N	TB
Golden-crowned Kinglet		TLC
Western Bluebird		TLC
Grasshopper Sparrow (rare)		TB, ES
Green-backed Heron	N	ED
Snow Goose		ED
Gadwall	N	ES
Redhead	N	ES
American Avocet	N	ES
Greater Roadrunner	N	UD
Downy Woodpecker (rare)		ED
Blue-gray Gnatcatcher		ED, UD
Warbling Vireo		ED, UD

2.3.3.3 Sensitive Wildlife Species

Without undeveloped corridors that provide abundant forage, cover, and water in the riparian and chaparral communities, large mammals would be excluded entirely from this area. The reserve could not contain or support the large territories required by these animals. Table 7 lists the sensitive animal species found in the San Elijo Lagoon area.

2.3.3.3.1 Sensitive Invertebrates

One insect species known to be threatened with extinction is found in the San Elijo Lagoon Ecological Reserve, the salt marsh skipper (Lepidoptera: Hesperiidae: *Panoquina errans*). The primary larval foodplant of this butterfly is salt grass. Although the reserve has suitable habitat for several sensitive species of tiger beetle (Cicindela sp.) and the globose dune beetle (*Coelus globosus*), a federal candidate for listing as endangered, these insects have not been observed (Figure 2.6).

2.3.3.3.2 Sensitive Reptiles

Seven sensitive reptile species have been documented at San Elijo Lagoon, and four additional reptiles and two amphibian species could potentially occur (see Table 7). Of these sensitive species, Hammond's two-striped garter snake and possibly California red-legged frog, southwestern pond turtle, and Hammond's spadefoot toad could be impacted by changes in water regimes. These species are discussed in detail in the Biology Appendix.

2.3.3.3.3 Sensitive Birds

Of the nearly 300 species of birds recorded at San Elijo, 78 are considered sensitive. Sixteen of these sensitive species nest within the reserve (Table 7). The Biology Appendix discusses sensitive species in detail, and includes candidates for formal listing and species of special concern. The following five species have been formally listed as State and/or Federal endangered or threatened and should be taken under consideration by enhancement projects affecting the hydrology of San Elijo Lagoon.

The California brown pelican (*Pelecanus occidentalis californicus*) is listed as endangered by both state and federal agencies. The pelican is a common non-breeding visitor along Cardiff Beach and offshore, foraging and roosting in the lagoon. Pelican activity is most prevalent in the central basin, particularly roosting on the narrow island northeast of Rios Avenue. Numbers and frequency of sightings are low from late winter to midsummer but increase dramatically in late summer (July through October). During post-breeding dispersal, 100 to 200 are typical in the central basin; more than 1,200 were recorded in August 1988.

The light-footed clapper rail (*Rallus longirostris levipes*) is a secretive and sedentary resident typically inhabiting cordgrass-dominated lower salt marsh. It is considered endangered by both

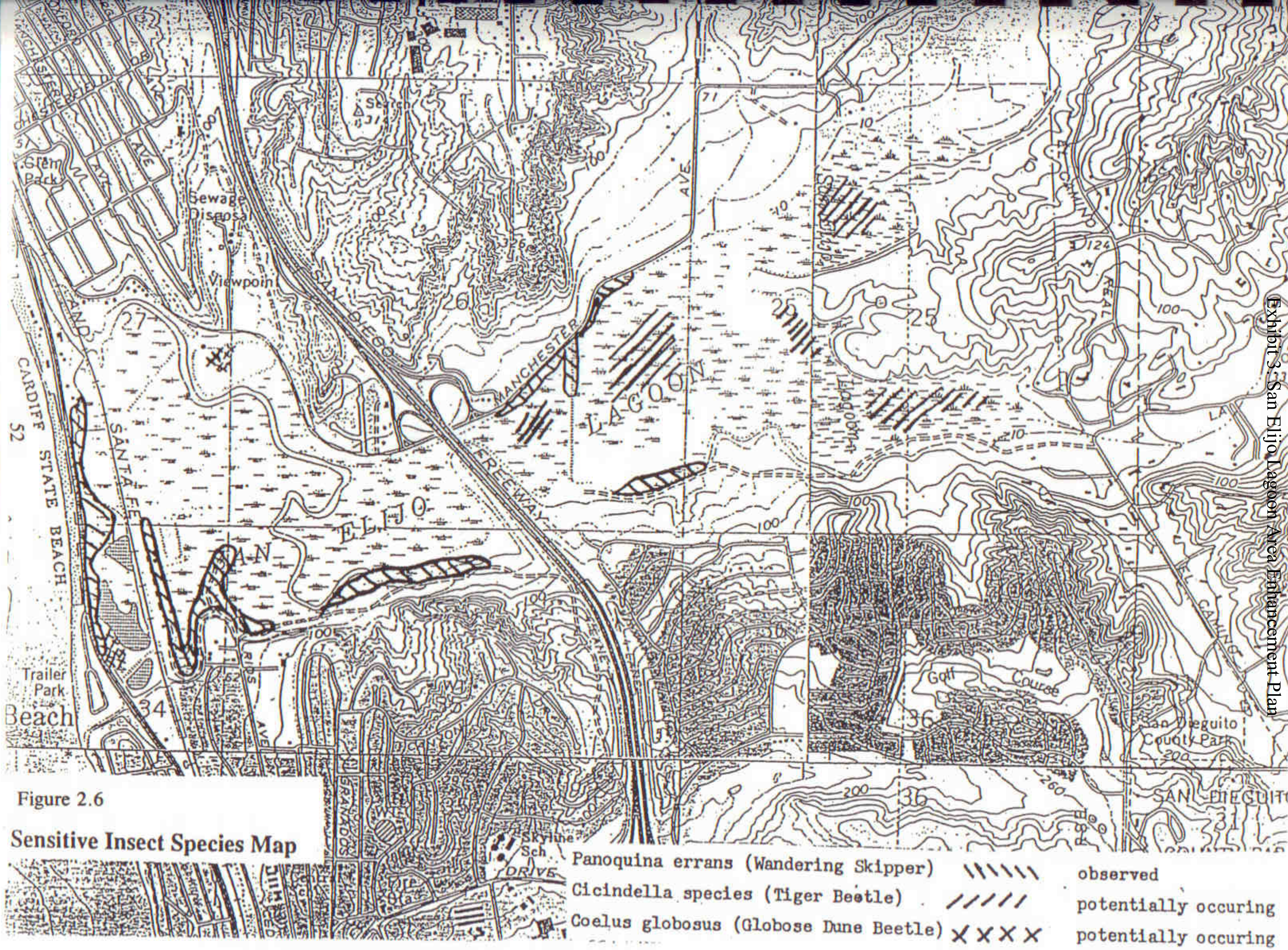


Figure 2.6

Sensitive Insect Species Map

state and federal agencies because of habitat loss and degradation. The countywide population crashed to a low of 142 pairs in 1985 and has slowly recovered.

Clapper rails have been observed as far east on Escondido Creek as the edge of cattails northeast of the Rancho Santa Fe Road-La Bajada crossing. The water level control and stocking of mosquito fish in 1992 may have benefitted clapper rails. Six to ten pairs were detected in 1993 in both the east and central basins. The rail is a year round resident at San Elijo Lagoon, commonly heard calling in the evening, although it is rarely seen (Figure 2.7).

The western snowy plover (*Charadrius alexandrinus nivosus*) is federally threatened and a state second priority species of concern. Predation, loss of beach sand, fluctuating water levels, and region-wide population decreases have made sightings sporadic at San Elijo. In 1992 and prior to 1984, they were fairly common migrants and visitors to the lagoon mudflats and Cardiff Beach, and were localized breeders in the east basin on salt panne and the tern islands. Numbers increase in the lagoon, particularly in the east basin, as water levels drop from April through August. They are most numerous as they migrate in late July through August. The maximum recorded was 74 in December 1982 (King et al. 1987).

Snowy plovers require sandy strand or salt panne habitats for nesting, with adjacent shallow channels and mudflats for access to aquatic invertebrates for their precocial young. Since 1992, an increase in plover numbers corresponds with the water level management practiced begun in that year by County staff in an effort to maintain lower water levels and increase available nesting and foraging habitat (Figure 2.8). Failure to maintain such levels in 1993 resulted in only five nests and poor hatching success due to flooding and egg adherence to the damp substrate.

The California least tern (*Sterna antillarum browni*), a state and federally endangered species, is a regular and common migrant and breeder at San Elijo. The terns usually arrive in late April, nest from May to July, then depart on their southward migration by mid-September. They nest in colonies on salt panne, on patches of sand on alluvial fans and channel edges, and on the two islands in the east basin north of Santa Carina that were constructed by the California Department of Fish and Game and San Diego County Public Works in 1981. Despite poor nest success, the San Elijo colony has persisted at least since the mid 1970s (see Figure 2.8).

Freshwater marsh vegetation encroaching on the east basin islands has increased the number and proximity of potential predators such as night herons and raccoons. Beginning in 1989, the majority of nesting by least terns shifted to the salt panne on either side of the dike. Although this shift initially reduced predation, the colony is more subject to disturbance by changing water levels.

The Belding's savannah sparrow (*Passerculus sandwichensis beldingi*), a state endangered species and federal candidate, is a very common resident of the salicornia marsh at San Elijo Lagoon (Figure 2.9). King et al. (1987) noted a decrease in the population, probably due to encroachment of freshwater species into salt marsh areas caused by lack of tidal influence. They recorded a maximum of 120 in May 1977. Other censuses at San Elijo documented 17 pairs in

Exhibit 3: San Elijo Lagoon Area Enhancement Plan

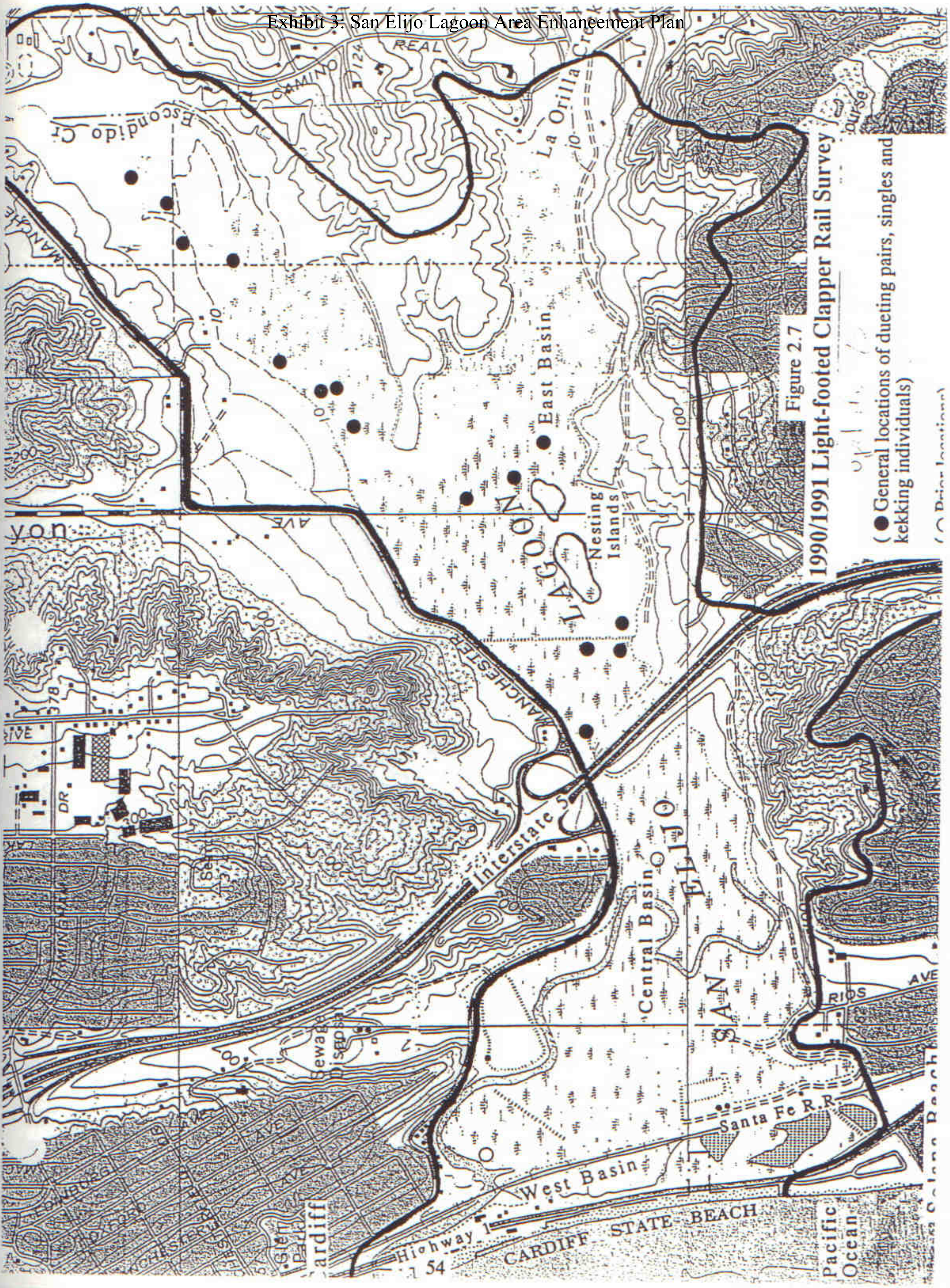


Exhibit 3: San Elijo Lagoon Area Enhancement Plan

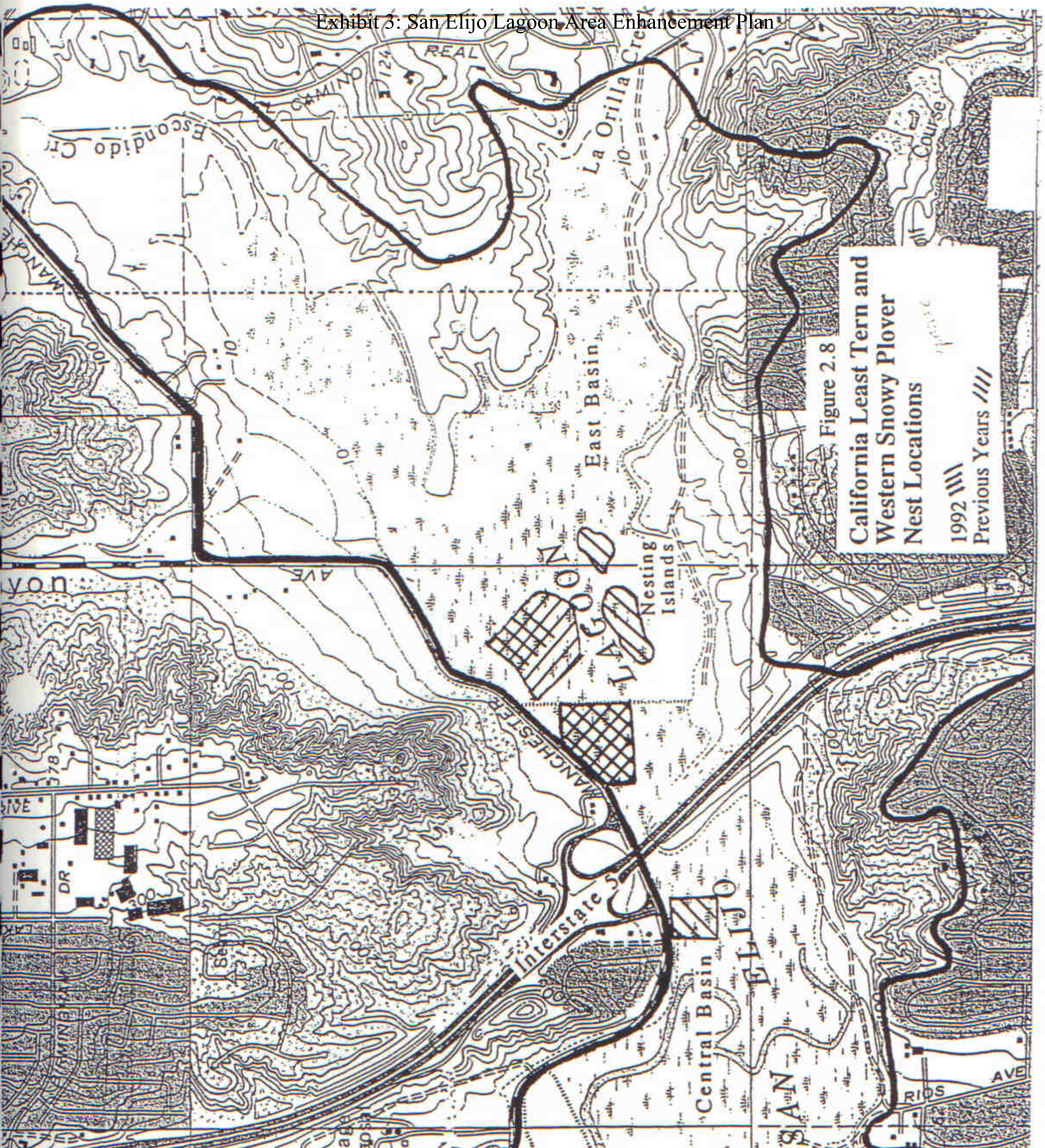


Figure 2.8
California Least Tern and Western Snowy Plover Nest Locations
1992
Previous Years

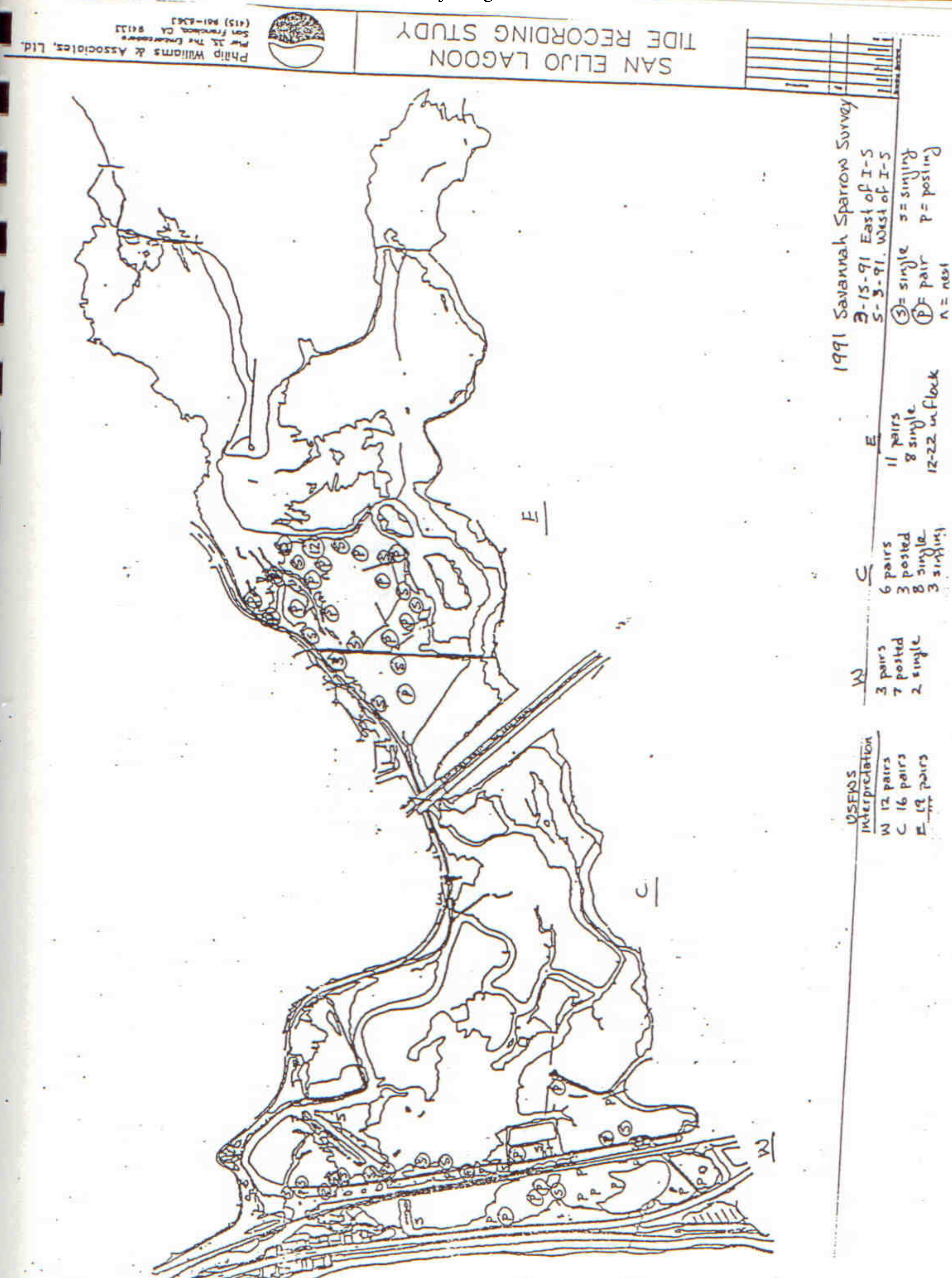

SAN ELIJO LAGOON
TIDE RECORDING STUDY
Philip Williams & Associates, Ltd.
1991 Savannah Sparrow Survey
3-15-91 East of I-5
5-3-91. West of I-5
(S)= single s= singing
(P)= pair p= posting
^ = nest
E
11 pairs
8 single
12-22 in flock
C
6 pairs
3 posted
8 single
3 singing
W
3 pairs
7 posted
2 single
USFWS Interpretation
W 12 pairs
C 16 pairs
E 19 pairs

Figure 2.9

1973, 30 in 1977 (Massey 1979), and 31 in 1986 (Zembel et al. 1988).

Savannah sparrow distribution at San Elijo appears linked to salicornia adjacent to channels that maintain some water and salinity throughout the breeding season, as opposed to those that dry out or contain only fresh water. This may relate to invertebrate prey abundance and supports the need for tidal restoration (J. Boland, pers. comm.).

The following are sensitive upland or riparian species that should not be affected by changes in the water management regime:

The California gnatcatcher (*Polioptila californica*) is a state species of concern, federally threatened resident restricted to coastal sage scrub. However, this species has increased in the immediate vicinity of San Elijo over the past fifteen years. Sightings since 1986 in all areas of sage scrub within the reserve indicate a population of 10 to 18 pairs with at least 5 additional pairs on adjacent private property (Figure 2.10).

The high density of gnatcatchers at San Elijo relative to more inland territories such as Mission Trails, Poway, and Sweetwater Reservoir may be due to the population being compressed into the only remaining available habitat. However, it is likely that the increased prey base available next to a wetland and more lush maritime sage scrub are able to support higher densities of birds than at inland sites (Billock 1990 and others).

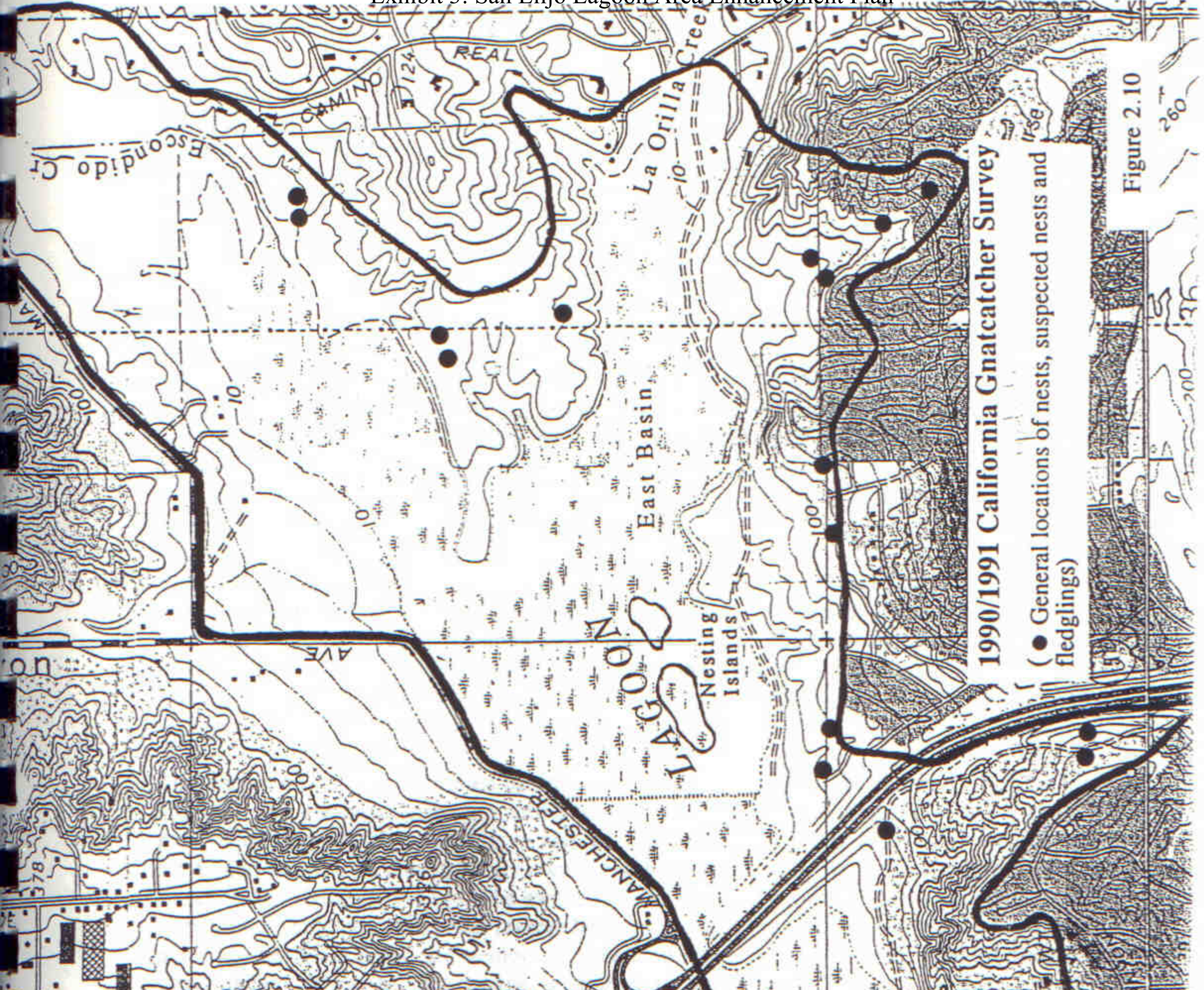
The gnatcatcher population at San Elijo Lagoon must have physical habitat connections to other populations if it is to remain viable, both for genetic exchange and to allow dispersal of young birds from San Elijo. Canyons with coastal sage scrub north of the eastern end of the reserve are particularly important, as gnatcatchers have been observed crossing Manchester Avenue to coastal sage scrub adjacent to Escondido Creek.

The least Bell's vireo (*Vireo bellii pusillus*) is state and federally endangered primarily due to loss and degradation of riparian habitat, but also from cowbird parasitism and predation. It is a rare visitor to San Elijo that has been recorded in most patches of willow scrub within the Reserve. Most willow scrub in the reserve is fairly dense, of the same age, and lacking the necessary understory diversity for nesting by the vireos. Riparian areas upstream may be more suitable. The potential for Bell's vireo success in riparian areas within the reserve would improve with reduced human disturbance, removal of non-native plants that prevent understory development, and reintroduction of native understory plants.

2.3.3.3.4 Sensitive Mammals

Three mammal species occurring at San Elijo Lagoon are considered state species of special concern and federal candidates for listing as endangered (see Table 7). The San Diego black-tailed jackrabbit has declined because of habitat fragmentation and loss. The northwestern San Diego pocket mouse and southern grasshopper mouse have also suffered from habitat loss and

Exhibit 3: San Elijo Lagoon Area Enhancement Plan



from increased predation as family pets are introduced into the area. These problems are further compounded by the loss of connections to open space for the migration of replacements.

2.4 RESERVE MANAGEMENT

2.4.1 Trails and Public Access

San Elijo Lagoon accommodates approximately 50,000 visitor-days per year, with a visitor-day defined as one visitor per one day or any portion thereof. At present, the public has access to eight miles of trail system in the reserve. To a great extent, these trails follow old road beds or currently maintained utility roads, most of which have been in existence for many years. Most of the reserve boundary is not fenced, and vegetation, topography, and private property limit access except at designated trailheads.

Fish & Game Reserve regulations are posted at all sanctioned access points at trailheads, at intervals along the reserve boundary, and at points where undesirable access has proved to be a problem, usually in sensitive habitat or known endangered species areas. Signs are susceptible to vandalism and must be frequently replaced in some areas. In addition, use of closed or re-routed trails, or off-trail activity, is discouraged by additional signage. Given the number of visitors to the area, game trails can rapidly become foot paths.

The reserve trail system is limited by the surrounding private lands. To the west, the SDNR and Highway 101 are impediments to access to and from the beach. Developed property abuts the reserve on the southern boundary, and Manchester Avenue lies along the northern side. Escondido Creek is largely privately owned and prone to flooding for a portion of the year. The Rancho Santa Fe trail system to the east is private, but does contribute some equestrian traffic. New trail development within the reserve has been reduced because of the abundance of sensitive plant and animal species, archaeological sites, and steep, sensitive terrain with erodible soils. Legal public access to the reserve is limited to daylight hours only. Ongoing after-dark disturbance to wildlife continues to occur, however, because the reserve is unfenced.

At present, the major trail beginning at N. Rios Avenue crosses private land for the first several hundred feet. It is possible that development of the property may result in the granting of an easement to allow continued public access to the reserve at this point.

A parking lot, shade structure, and equipment yard have been constructed at the site of the anticipated nature center, on Manchester Avenue in Cardiff. This site features convenient access from the freeway and a half-mile loop trail with good birdwatching opportunities. When funding becomes available, future construction may include interpretive trail signage, handicapped access, a public restroom, and a small visitor information facility.

The most frequent forms of public use of the reserve are passive, including birdwatching, jogging, and hiking. Most use occurs along the major trail along the south shore of the lagoon. Fishing is allowed where trails access the water edge, limiting this activity to a few spots where the deeper channels are adjacent to the trail. Horseback riding is allowed east of Interstate 5. The trail continues west from Rios Avenue, but access to the beach involves crossing the SDNR tracks, a hazard that the railway company is discouraging through citations.

The previously mentioned USFWS-funded excavations of the lagoon in 1994 and 1995 allowed the lagoon to remain open during those summers. Although there had been some concern about the impact of these projects on recreational beach use, the warm shallow waters of the tidal mouth were a favorite location for recreational swimming. An open mouth did not appear to have any effect on wave conditions or surfing. The heavy equipment needed to move the cobble from the mouth was also used to knock down the high cobble berm along the entire length of the beach, allowing easier beach access to visitors.

2.4.2 Resources Monitoring

County Parks Department staff currently monitor vegetation, wildlife, and water levels. Monthly bird counts are conducted for long-term quantitative comparisons, and nesting numbers of least terns and snowy plovers are monitored and contributed to state and regional survey efforts. Fish, invertebrates, and water quality are monitored by SDSU and PERL through County Parks and San Elijo Conservancy contracts. SDSU has monitored bacteriological levels under a grant from EPA through County Parks. See Appendices for monitoring details.

2.4.3 Lagoon Inlet Management

Since 1986, the County Parks Department has been the lead agency in managing the lagoon. Staff has monitored and attempted to assess and quantify various factors affecting lagoon management by relying on data and recommendations from the USFWS, DFG, San Elijo Lagoon Conservancy, San Elijo Lagoon Foundation, PERL, Philip Williams and Associates, and other consultants. This has resulted in attempts at managing water levels and quality to benefit the health and diversity of native plants and animals through more frequent openings of the lagoon mouth. Indicators that have been monitored include water level relative to mean sea level, salinity, dissolved oxygen, and diversity and numbers of wetland-dependent plants, invertebrates, fish, and birds.

The lagoon opening to the ocean has been restricted to a narrow channel with two 90-degree turns leading from the northwestern corner of the central basin, under the railroad trestle, then northwest under the Highway 101 bridge and across the beach. Del Mar claystone underlies the northern extent of the channel, limiting depth, and continues offshore as the "Cardiff Reef," affecting waves, currents, and sand and cobble deposition in the lagoon mouth. Siltation throughout the lagoon, expanding areas of freshwater and brackish marsh vegetation, and manmade structures such as Highway 101, the fill for Interstate 5, the railroad tracks, the east basin dike, and Manchester Avenue are constraints to natural or historic tidal prism and water flow patterns through the lagoon.

If the lagoon is in a closed condition, it typically opens to the ocean naturally as the water level rises with fall and winter rains to a point that it overflows the sand and cobble beach berm and erodes a channel through the berm. This berm is deposited across the mouth of the lagoon through summer sand accretion from longshore sand transport by the ocean currents.

In the past, when water levels in the closed lagoon would rise and flood roadways or threaten sanitation facility functions, County Public Works used heavy equipment to breech the beach berm. High populations of mosquitoes has, at times, led County Health Department Vector Control to open the lagoon. In addition, the threat of fish kills, avian botulism, or flooding of endangered species nesting areas resulted in State Fish and Game opening it to the sea.

The success of lagoon openings is influenced by water level within the lagoon, tidal conditions, and beach substrate composition. At low water levels, little natural channel scour is achieved, and duration of tidal exchange is short. However, at high water levels in the lagoon, channel scour is extensive and prolonged, resulting in a wider, deeper inlet channel and increased likelihood of prolonged tidal exchange.

A beach composed of sand is easily worked by both equipment and water flow, whereas cobbles are not so easily moved. The optimal condition for an opening is a high lagoon water level with a beach berm consisting of sand. Such conditions frequently lead to natural openings. A small pilot channel may be started by hand or heavy equipment, after which the force of the water exiting the lagoon scours a wide, deep channel and redeposits the sand along the beach. The least desirable extreme is of low lagoon water levels and berm content of cobbles. This requires extensive excavation by heavy equipment.

From 1986 to 1993 the lagoon inlet was opened to the ocean an average of five times per year; one to three times naturally as a result of rising lagoon water levels, and up to five times artificially using heavy equipment. Excavation occurred in the channel alignment west of the Highway 101 bridge, relocating up to 6,000 cubic yards of material to the beach. Target channel depth was MSL to two feet below MSL with channel width 12 to 60 feet. At times, lagoon water outflow deepened and widened the channel significantly. Reopenings were attempted on some occasions when sand flow closed the mouth too quickly.

In 1986 and 1989, excavation of up to 8,000 cubic yards of sand was necessary in the channel east of the Highway 101 bridge. This material had been deposited by severe winter storms. It was found that excavation alone west of the bridge was insufficient to restore adequate flow in the channel. Such excavation will be required periodically if the current management regime is continued.

Projects in 1994 and 1995 involved the excavations of up to 10,000 cubic yards of material west of the bridge. These projects were funded by a grant secured by the San Elijo Lagoon

Conservancy from the U.S. Fish and Wildlife Service and San Diego County Parks and Recreation Department in an effort to duplicate management techniques routine at Los Peñasquitos Lagoon. The hypothesis was that removal of the cobble berm at San Elijo in spring would be as successful in maintaining prolonged tidal action as it has at Peñasquitos. The channel was excavated to three feet below MSL and remained open until late summer without additional modifications.

The success of these two spring excavations shows great promise if further funding to continue this practice can be secured. The excavations enabled salt water to reach areas that previously had been inundated by freshwater runoff during summer-long closure, thereby allowing salt marsh vegetation to replace freshwater species. Also, the resultant tidal exchange in the western and central basins during the spring and summer months has revealed sedimentation damage to the lagoon. Significant areas of mudflats, previously underwater during periodic lagoon closure, are often too high to be inundated during tidal influx. This subject needs further documentation.

Necessary permits for such management have been obtained from State Lands Commission, DFG, California Coastal Commission, USFWS, and US Army Corps of Engineers. The following criteria have been used to determine the necessity of effecting a lagoon opening:

A) Salinity

In an estuary system, problems can arise from prolonged periods of salinity extremes. Organisms will succumb from too little, as well as too much, salt in the water. Fresh water has a salinity of 0 parts per thousand (ppt). Seawater is 33 ppt. Biological damage can occur below 10 ppt (hyposaline) or above 50 ppt (hypersaline).

In recent years, San Elijo Lagoon has experienced increasing year-round run-off from Escondido Creek, and from storm drains along the lagoon margins. This water, while containing pollutants, nutrients, and other undesirable material, is essentially "fresh" water. When this water collects in the lagoon because of blockage of the mouth, it dilutes the existing salinity, causing the water body to become hyposaline. It has been observed that this decreased salinity permits the establishment and growth of freshwater vegetation such as willow, cattail, and tule in areas formerly entirely covered by salt marsh vegetation. The reduced salinity also permits the proliferation of insect pests such as mosquitos, gnats, and midges.

Hypersaline conditions can occur when the mouth of a lagoon becomes blocked and the evaporation of the resulting trapped water leaves behind salts that are not diluted by incoming fresh water or by seawater. The resulting environment is far saltier than the sea, and can be much too salty to support normal estuary plant or animal life.

While hypersalinity has not been a large factor in recent lagoon openings, hyposalinity has figured prominently. If prolonged, either situation must be considered as detrimental to a healthy salt marsh. In addition, the radical shifts in salinity caused by occasional opening after extended closed periods does not allow the establishment of a permanent invertebrate prey base (crabs, worms, etc.), resulting in a less varied diet for the wildlife dependent upon it. Fluctuating salinity levels also severely impact fish populations and reduce the spawning potential for marine fish using the lagoon.

B) Water levels

While closely tied to salinity, water levels can affect the health and, more particularly, the reproductive success of many species. Although water level fluctuations are regular with tidal action, extreme levels for a prolonged period when the lagoon mouth is closed are a major concern.

The most obvious adverse condition is that of extreme high water level. In this case, considerable shoreline vegetation is submerged, a condition that will kill the plants if prolonged. Also, mudflats are completely inundated, restricting or eliminating foraging areas for shorebird species. Low vegetation, algae, and invertebrates are unavailable to dabbling ducks. Nesting sites for endangered bird species such as the Belding's savannah sparrow, California least tern, and snowy plover are reduced or nonexistent, as are nesting sites for many other bird species. Under conditions of high water levels, any nesting that does take place is under immediate threat of flooding if the addition of water from a sudden storm should occur. Even "normal" urban run-off can bring levels up to impair breeding success if it occurs between egg-laying and hatching.

Low water levels can result in predators having increased accessibility to islands formerly protected by water. Increased predation on eggs and young by native predators and neighborhood pets, as well as the increased disturbance by human beings, are undesirable results of low water levels. Low water levels also reduce habitat for fish and invertebrates. Subsidence (the drying, decomposition, and shrinkage of organic anaerobic soils) has long-range effects as the bottom contour of the area lowers and compacts.

Monitoring of water surface elevations and bird use of San Elijo Lagoon by San Diego County Parks Department biologists has determined that at a water surface elevation of 2.90 feet above mean sea level (MSL recorded on the Interstate 5 overpass), approximately 90 percent of mudflats necessary for shorebird foraging is submerged and unavailable. In addition, salicornia necessary for nesting by State Endangered Belding's savannah sparrows becomes inundated at this water level. At a water surface elevation of 2.10 ft. above MSL, extensive areas of bare substrate are exposed.

Water surface elevation monitoring posts were installed at several locations in San Elijo Lagoon in the 1970s and have been monitored at times of water level changes by Parks Department staff since 1986. Additional gauges were installed by the Philip Williams & Associates hydrology firm in September, 1990 and have been regularly monitored by Parks staff since that time. Avian use of the lagoon has been monitored informally on a daily basis by Parks biologists and formally in monthly bird censuses of a representative area of the northwestern central basin of the lagoon since fall of 1986. Additional data is supplied by quarterly shorebird counts organized by Point Reyes Bird Observatory and annual nest and foraging monitoring of endangered species in conjunction with U.S. Fish and Wildlife Service and California Department of Fish and Game.

C) Water quality

This category includes salinity, temperature, the presence of potentially toxic algae (blue-green), nutrients, pollutants, and the capacity of the water to carry dissolved oxygen (DO). While some tests are performed on an ongoing basis, observations of water turbidity, temperature, weather conditions, and unpleasant odors are useful considerations in field estimation of poor water quality.

Water quality deteriorates more quickly in salt water than in fresh, because less oxygen is held in salt water, especially under warm conditions. Reduced oxygen, whether produced by anaerobic decomposition of vegetation, excessive numbers of organisms respiring (fish, etc.) or a combination of factors, can lead to eutrophication (the condition where a closed body of water can "turn over.") Large amounts of methane and hydrogen sulfide gas are released at the bottom and absorbed into the water, causing the deaths of most organisms within that water column and resulting in extremely unpleasant environmental and aesthetic conditions.

The Pacific Estuarine Research Laboratory (PERL) of San Diego State University has tested oxygen, salinity, and temperature biweekly and taken quarterly fish and invertebrate samples from San Elijo Lagoon from 1989 to 1994. Comparative long term studies with other San Diego County wetlands, including Los Peñasquitos Lagoon and Tijuana Estuary, led them to conclude that a dissolved oxygen level of 4 mg/liter is considered to be the minimum level for adequate water quality even without eutrophication. Oxygen levels below 4 mg/l lead to stress and death in fish and invertebrates.

D) Health Department concerns

The Health Department actively monitors the lagoon and adjacent wetlands for the presence and breeding activities of insects, especially those known to transmit diseases to humans and livestock. Documented cases, mainly around Buena Vista and San Dieguito lagoons and the Tijuana Estuary, indicate that under the right conditions, the possibility exists at San Elijo for the insect-vectored transmission of diseases such as malaria and encephalitis. If possible, the Parks Department cooperates with the Health Department when they indicate that the lagoon level should be altered to eliminate mosquito breeding sites.

At times the Health Department receives requests from the public to remedy a nuisance problem concerning the presence of large numbers of a species of freshwater midge. These insects can build up to large numbers and can be a concern to property owners adjacent to the lagoon, especially in the central basin. While this is a relatively natural phenomenon around a wetland, it has been exacerbated in recent years by increasing freshwater run-off during the summer, which allows the salinity to drop to levels tolerable to this insect.

E) Biological issues

These issues are the hardest to quantify and include relatively subjective judgment about such things as condition of vegetation, readiness for nesting based on observation of breeding behavior, and condition of the habitat to support nesting and foraging. Most of the biological issues relate directly to water levels in the lagoon.

2.4.4 East Basin Management

Water levels in the east basin of San Elijo Lagoon are controlled through manipulation of two 36" diameter gate valves and flashboard risers on corrugated metal pipes through the east basin dike. The existing dike structure was constructed by DFG and County Public Works in August 1981 over remains of dikes that date from the 1880s. Gate valves are located at the north and south ends of the dike with spillways adjacent to each. The dike itself is approximately 7.5 ft. above MSL and the spillways 5.5 ft. above MSL. Engelhorn (1979) proposed management and monitoring procedures for the project, and Novick and Lauppe (1982) proposed an interim management plan to DFG that County Parks staff follows.

During summer, gate valves are opened completely to draw down the area east of the dike, allowing salt panne to dry and provide nesting area for least terns and snowy plovers, and salicornia for savannah sparrows. This also limits mosquito breeding. A water level of 3.0 ft. above MSL is maintained, keeping the deepest channels flowing to protect nesting islands. The gate valves are closed in November, creating mudflats and inundated areas for foraging at 4.5 ft. above MSL to benefit fall migration of shorebirds and waterfowl. To benefit wintering waterfowl, in December damboards are added to the valve risers to raise the level to 5.5 ft. above MSL. To benefit spring shorebird migrants and reduce mosquito breeding, boards are removed in March to draw down water levels and then gate valves are opened in April.

Zedler (pers. comm.) has proposed using the gate valves to release "pulses" of water to help maintain open lagoon channels and reduce the impacts of fresh water to the salt marsh. The gate valves have been opened prior to lagoon openings to maximize the volume of water west of Interstate 5 that is available for channel scour following the initial berm breach.

They also have been opened at flat tides to enhance channel scour and outflow to counter wave action depositing sand and threatening mouth closure. However, the relatively small volume of water carried through the gate valves and the length of time that it takes to influence levels west of the dike make their use in generating "pulses" less than optimal.

2.5 LAND USE PLANNING CONTEXT

2.5.1 OWNERSHIP OF SAN ELIJO LAGOON

San Elijo Lagoon is owned by the California Department of Fish and Game (DFG), the County of San Diego, the San Elijo Foundation, and private landowners. In addition, the State Lands Commission owns some parcels leased to DFG. The three basins have been combined by agreement between the County and DFG and are managed as the San Elijo Lagoon Ecological Reserve, as part of the Department of Fish & Game's reserve system. A County park ranger is responsible for the daily management of the reserve.

2.5.2 ZONING

Land use zoning for the area primarily consists of mixed density residential and occasional occurrences of other uses including educational (Mira Costa College), religious (Greek Orthodox Church), agricultural, and recreational (State beaches). Most developable properties have been built out. In some cases, private landowners have donated the wetland portions of their property to the ecological reserve, pursuant to development permits by the California Coastal Commission. However, many private backyards directly border the reserve. Houses encircle the lagoon except on the western side, either directly encroaching on the wetlands or perched on the bluffs to the south of the lagoon. The reserve itself is zoned "Ecological Reserve/Open Space/Parks" in the Encinitas General Plan.

2.5.3 JURISDICTIONS

The majority of the lagoon is included within the city limits of the City of Encinitas, most of which lies to the north. The City of Solana Beach bounds the southern side of the lagoon and includes Holmwood Canyon and the Solana Hills extension within the city limits. The unincorporated area of San Diego County lies to the east and includes parcels of the northeastern corner of the reserve along Escondido Creek. To the west is Highway 101 and a small area of privately owned businesses, beach, and open ocean. San Elijo State Beach campground is directly north of the lagoon mouth, and Cardiff State Beach is directly south of the lagoon mouth. These facilities are owned and operated by the State Department of Parks and Recreation. The County of San Diego holds an easement over State Park lands where the lagoon channel crosses the beach.

2.5.4 UTILITY EASEMENTS

Several water and sewage lines cross the lagoon, and three water districts have water lines in the reserve: the Santa Fe Irrigation District, the Olivenhain Municipal Water District, and the

San Dieguito Water District. Four sanitation pump stations feed sewer lines that border or cross the lagoon: the Cardiff Pump Station, the Olivenhain Pump Station, the San Elijo Hills Pump Station, and the Solana Beach Pump Station.

Various other utility easements, including cable television, telephone, and electrical, exist for both underground and above-ground installations. Natural gas lines cross the reserve in two places: adjacent and parallel to the railroad tracks, and east of Interstate 5 running north to south adjacent to above-ground power lines. A petroleum pipeline also shares this easement near the eastern end of the reserve.

Numerous other easements exist for roads and access purposes. Few of these could be developed, as the sensitive nature of the sites should preclude disturbance.

2.5.5 Local Plans and Policies

2.5.5.1 City of Encinitas

Encinitas General Plan Land Use Categories. Of the 18 land use categories described in the Encinitas General Plan, four apply to land abutting the lagoon boundaries ("Rural Residential 2," "Residential 3," "Residential 11," and "Public/Semi-Public"), and one applies to the lagoon itself ("Ecological Resource/Open Space/Parks"). These categories, through the zoning ordinance, dictate type, intensity, and density of development and are recorded on a series of "Land Use Policy Maps" contained in the General Plan. Following is a description of the five land use categories affecting the lagoon.

The Ecological Resource/Open Space/Parks category specifies, "This land use designation includes all land that has been permanently set aside for the public's use or for the preservation of areas deemed ecologically significant... This category includes public parks...the beaches, wilderness preserves, *San Elijo Lagoon*...." This category is especially important in establishing the lagoon as a non-generic, easily identifiable geographic entity given legitimacy in the Encinitas land use planning process.

The land use designations of land immediately surrounding the lagoon consist of "Rural Residential 2," "Residential 3," "Residential 11," and "Public/Semi-Public." The residential categories allow increasingly denser development on a per acre basis. Under the Rural Residential 2 category, the highest density permitted is from 1 to 2 units per acre with a minimum lot size of one-half acre. The highest density of development permitted is Residential 11, which allows from 1 to 11 units per acre.

The Public/Semi-Public category is for land and facilities, such as schools and libraries, owned and operated by a public entity.

Encinitas General Plan Elements. Of the seven elements constituting the Encinitas General Plan, the Land Use and Resource Management elements are most relevant to San Elijo Lagoon. The City of Encinitas has made an effort to influence development in the areas of the city falling within the lagoon watershed by acknowledging the sensitive nature of the wetlands and imposing controls on some forms of development. They identify erosion, sedimentation, and degradation of water quality as problems to be avoided. They also designate viewsheds and advise buffers between development and wetlands.

While the city has no actual jurisdiction over the San Elijo Lagoon Ecological Reserve itself, development in the Escondido Creek watershed within the city limits directly impacts the water quality of the lagoon and the biological integrity of the reserve.

2.5.5.2 City of Solana Beach

The City of Solana Beach is south of San Elijo Lagoon and the City of Encinitas. The city is approximately 95% developed, according to the General Plan completed in 1988. Therefore, future development in the city will primarily involve recycling of currently developed parcels and infill development of the city's few remaining vacant parcels. The areas where future redevelopment of developed parcels and infill development will have the greatest impact on the reserve include areas along Highway 101 and North Rios Avenue. Vacant land in this area should be reviewed carefully for potential impacts on the reserve and lagoon.

Solana Beach General Plan Elements. Two general plan elements, Land Use and Conservation and Open Space, are most relevant to the enhancement and management of San Elijo Lagoon. They also address erosion and sedimentation, and recognize the sensitive resources of the San Elijo Lagoon area.

2.5.5.3 County of San Diego

The County of San Diego, one of the major landholders in the San Elijo Lagoon area, has entered into an agreement with the California Department of Fish and Game to maintain the entire lagoon and adjoining open space as a State Ecological Reserve. At present, the Parks Department has staff assigned to the reserve to monitor biological conditions, maintain trails, combat erosion and invasive exotics, and to provide the public with information and assistance, while reducing visitor impacts to the resource.

In addition, the County of San Diego is the local agency providing sheriff and animal control services for the area. These services have been contracted by the local cities with the County. The Department of Health is involved on a county level with the Division of Vector Control, which is charged with the responsibility of protecting public health, and to regularly monitor and control potentially disease-transmitting mosquitoes.

2.5.5.4 State of California

The State of California, Department of Fish and Game, is the other major landholder at San Elijo. As one of the Department's Ecological Reserves, San Elijo is subject to regulations designed to reduce impacts to sensitive resources. The department is also charged with the protection and enhancement of sensitive, threatened, or endangered plants, animals, or communities. San Elijo is under the supervision of a Department of Fish and Game reserve manager, and is subject to enforcement of regulations by Fish and Game wardens.

Additional State agencies involved in this area include the Coastal Commission, Regional Water Quality Control Board, State Lands Commission, State Department of Health (which is administered on a County level), California Department of Parks and Recreation (for activities affecting the beach and beach recreation), and Caltrans (anything affecting the right-of-way of Interstate 5).

2.5.6 Coastal Planning - Local Coastal Plans

Pursuant to the California Coastal Act, all local coastal jurisdictions are required to prepare Local Coastal Programs (LCPs) to implement the policies of the Coastal Act. In 1995 the LCP for Encinitas was approved. The Coastal Commission retains jurisdiction over projects directly impacting the San Elijo Lagoon Ecological Reserve, and decisions on other projects may be appealed. Unlike Encinitas, the City of Solana Beach has not yet begun the process of LCP preparation and is currently using the San Diego County LCP policies.

2.5.7 Resource Oriented Plans

At least two plans prepared in the late 1970s (San Elijo Lagoon East Basin Water Management Plan and Draft San Elijo Lagoon Regional Park Master Plan), one plan prepared in 1990 (DFG Interim Management Plan), and one plan prepared in 1993 (SCS) have attempted to address resource management issues of the lagoon. Many of the recommendations of the two earlier plans have been implemented. The general goals and objectives of these four plans have been incorporated into the San Elijo Lagoon Enhancement and Management Plan, which comprehensively addresses the entire lagoon area system.

The **East Basin Water Management Plan** was prepared for the San Diego County Department of Sanitation and Flood Control by the Smith/Williams Group in 1976. The plan's primary objective was to identify water management strategies that would improve the freshwater or brackish water marsh of the east basin while providing flood and vector control. The plan also identified problems with the existing marsh. To enhance the area for waterfowl and other freshwater and brackish water species, the plan recommended repairing existing dikes, dredging existing channels and a 17-acre pool, removing excessive cattails, and stocking mosquito fish. The plan emphasized controlling the water levels to achieve the objectives. These recommendations have been implemented and are basically the management patterns practiced by the County Parks and Recreation staff. Additionally, the plan recommended the following management measures:

- Utilize surface runoff in Escondido Creek as the primary source of water and obtain water from local water districts as a supplement.
- Monitor lagoon level, rainfall, streamflow, vegetation type and extent, sediment volume, and inflow for efficient operation of the water management portion.
- Continue monitoring of Escondido Creek's water quantity and quality by the Regional Water Quality Control Board.
- Investigate water rights for Escondido Creek's surface flow. Four upstream impoundments exist; establish the rights for lagoon supply.
- Additional study on the effect sedimentation has on the east basin. Consider an upstream sediment reservoir or flood bypass channel.

Of these management measures, the County monitors lagoon level and rainfall; there is a streamflow measurement device in Harmony Grove; and the RWQCB continues to monitor water quality in Escondido Creek. However, the use of potable water and the investigation of water rights for lagoon supply was not pursued, and only a general initial sedimentation study has been completed (Barry et al. 1976; USDA 1993). A comprehensive sediment study analyzing volume and the effects of sedimentation on the lagoon has not been completed. The objectives articulated in the 1976 East Basin Water Management Plan of increasing freshwater habitat in the eastern part of the lagoon have been broadened to the current planning objectives of improving the entire range of habitats in the lagoon area from salt marsh in the western end to riparian and upland in the eastern end.

The **Draft San Elijo Lagoon Regional Park Master Plan** was prepared for the County of San Diego Department of Parks and Recreation by Smith and Williams in 1977. This draft plan recommended a program to implement the regional park goals of "preservation and enhancement of the lagoon's flora and fauna and access to the lagoon with educational/recreational opportunities for the visitor." The plan recommended water management for the east basin and a managed ocean opening in the west basin. These actions were proposed to "permit the west basin to become a tidally flushing salt marsh and the central basin to develop as a brackish/freshwater marsh, thus providing maximum diversity in nesting, feeding, and resting terrain for a large variety of shorebirds and waterfowl." The action program consisted of the following recommendations:

- Complete land acquisitions as recommended in the Land Acquisition Report of December 21, 1976.
- Institute the recommended zoning changes in conformance with the "proposed zoning" map.
- Carry out the proposed East Basin Water management plan, as per report dated February 18, 1976.
- Following this, commence the proposed park improvements as indicated in the Master Plan of Park Development, completing them in phases as determined by the availability of funds.

- Concurrently with the park improvement project, complete the necessary utility work, including erosion control.
- Initiate an active docent program with the aid of the San Elijo Lagoon Foundation and volunteers.
- Enlist the assistance of the Museum of Man and/or a participating university or college and develop an archeological interpretive center and active display dig.
- Encourage through donation of land and/or funds the establishment of a scientific research station, with opportunities for recreational/educational exposure to the park's visitors.

This draft plan was never finalized. Out of the "action program," most of the recommended land acquisitions have been completed, although this component is ongoing and, as noted above, most of the East Basin Water Management Plan has been implemented. Many of the park improvement projects have not been realized. County staff has begun consolidating trails that are eroding or redundant and implemented several revegetation projects. A park office and visitor parking lot have been constructed.

The 1990 **CDFG Interim Management Plan** provides a basic framework for resource management through biological survey and land ownership information, and general recommendations for wildlife habitat improvements. These general recommendations are incorporated into the San Elijo Lagoon Enhancement and Management Plan, which adds information on basic physical features and processes: for example, the tidal and freshwater dynamics needed to formulate enhancement options and long-term management guidance for the lagoon.

The recent 1993 **Escondido Creek Hydrologic Area: Project Report** was developed by the USDA Soil Conservation District (SCS) for the San Diego Regional Water Quality Control Board. The report represents the first step in developing a Nonpoint Source Pollution Management Plan (NSPMP) for San Elijo Lagoon and the Escondido Creek Hydrological Area (encompassing approximately 54,200 acres). The objective of the NSPMP is to "identify methods which can be used most effectively to eliminate nonpoint source loading in the subject lagoon watershed." The report identifies the land uses in the watershed that are the source of the excess nutrients, chemical contaminants, fresh water, and erosion and sediment that have a negative impact on the lagoon biota and public health. The report quantifies the total amount of sediment, nutrient, and excess fresh water reaching the lagoon for each land use and from each of 12 subwatersheds. The report recommends the following actions:

- Implement a controlled burn program to reduce the production of erosion and sedimentation from large uncontrolled burns.
- Organize a watershed task force to oversee implementation and funding activities.
- Study further the nutrient and bacteria cycling characteristics of the lagoon. Dredging of portions of the lagoon may be necessary to increase tidal flushing and realize beneficial changes in the system.
- Change the grading ordinance to apply to development of agricultural lands. Include education programs for erosion control and nutrient management.
- Apply confined animal facilities requirements (for waste management) to animal operations.

- Develop education programs on water quality protection including stormwater and irrigation runoff, animal wastes, erosion and sediment, and septic tank problems.
- Expand existing technical assistance programs for erosion control and nutrient management in the hydrologic area.

2.5.8 Permits and Approvals

This document has been prepared to provide the Coastal Commission, agencies, and other interested parties with information about ongoing operations and maintenance. Implementation of large-scale projects recommended by the San Elijo Lagoon Enhancement Plan will require several permits and approvals from local, state, and federal agencies.

Local Level. At the local level, private property owners have the right to refuse or limit use of their property. Prior to implementing any dredging in the lagoon, the City of Encinitas will require grading and encroachment permits for activity within any of its easements. In addition, should parcels be acquired for conservation and enhancement that are now zoned residential, the site should be rezoned to reflect the newly proposed land use. Use of Highway 101 would be regulated by each city within their city limits.

Any proposed project may require permits and approvals from the County of San Diego (particularly with regard to regional development of public park facilities). Additionally, any proposed project may require approval from utility districts that own easements for water and sewer lines across the lagoon. Before any dredging in the lagoon is planned, the exact location of water and sewer lines must be identified and incorporated into the dredging plans. If a project proposes to establish new aquatic habitats for plant or animal species, the County Health Department may be involved in its capacity of vector control.

State Level. At the State level, all agencies must comply with the requirements of the California Environmental Quality Act (CEQA) regarding impact assessment. The California Coastal Act requires a coastal development permit for development activities within the coastal zone.

The State Lands Commission determines the existence of state-owned tidelands within California. In most cases, the doctrine of public trust provides a public easement over waterways and wetlands to the Mean High Water (MHW) line. Disturbance of these lands for reasons other than maintenance requires a lease or permit. In addition, the existence of public trust in a wetland must be determined before any public acquisition can occur.

There are three sections of the State Fish and Game Code that dictate regulatory roles for the Department of Fish and Game. Sections 1602-1603 require the DFG to review proposals to modify lands below the MHW line. The Department issues Streambed Alteration Agreements, which involve mitigation measures to protect ecological values. Sections 900 and 2050 require protection of endangered, threatened, and rare species, and Section 5653 controls dredging. In addition, the DFG plays a major advisory role to the Coastal Commission on wetland issues.

Under Section 402 of the Federal Clean Water Act, the Regional Water Quality Control Board (RWQCB) administers a permitting system for the control of water quality. The Board reviews a project to make sure that excavation of waterways does not cause unnecessary or unavoidable pollution. This regulation affects any water or waste discharge into a wetland such as San Elijo Lagoon, as well as the placing of dredge spoils. The RWQCB has a strong review role.

Finally, the California Department of Parks and Recreation regulates activities on State Park Lands, and the California Department of Transportation would require an encroachment permit for any activity in the right-of-ways of area highways (Interstate 5).

Federal Level. The National Environmental Protection Act requires responsible agencies to prepare Environmental Impact Statements for public projects that have a significant effect on the environment. The Environmental Protection Agency reviews the Water Resource Control Board's discharge permits under Section 402 of the Clean Water Act.

The Army Corps of Engineers issues two types of permits for projects that involve the modification of wetlands. Section 404 of the Clean Water Act gives the Corps permit jurisdiction over dredging and fill within wetlands and the disposal of dredge spoils. Section 10 of the Rivers and Harbors Act controls obstructions in navigable waterways. The Corps must grant permits for development of any structures that would effect navigable waters, including jetties, breakwaters, or any modification to offshore "reef" formations.

The United States Fish and Wildlife Service plays a major advisory role in all Section 10 and 404 permits. In addition, Section 7 of the Federal Endangered Species Act requires consultation with the USFWS if a proposed project could impact an endangered species.

The National Marine Fisheries Service also advises on all Corps permits that may adversely affect fisheries. The agency's main concern is with the welfare of the coastal estuaries and lagoons that serve as nurseries or feeding grounds for migrating ocean fish.

Table 8 provides a summary listing of the regulatory jurisdictions, permits, and approvals most likely to be involved during long-term implementation of projects proposed in the San Elijo Lagoon Area Enhancement Plan.

TABLE 8
San Elijo Lagoon Enhancement Plan
Regulatory Jurisdictions, Permits, and Approvals

GOVERNMENT AGENCY	LEGAL AUTHORITY	PRIMARY RESPONSIBILITY
FEDERAL		
U. S Army Corps of Engineers	Rivers and Harbors Act of 1899, Section 10 Clean Water Act, Section 404	Regulation of dredge and fill in "waters of the United States" including their adjacent wetland areas. Long-term monitoring of compliance with permit requirements.
U.S. Fish and Wildlife Service (USFWS)	Fish and Wildlife Coordination Act Endangered Species Act Marine Mammal Protection Act	Advisory comments to Corps regarding biological impacts of projects including migratory birds and endangered species habitat; also review permit compliance.
National Marine Fisheries Service (NMFS)	Fish and Wildlife Coordination Act Marine Mammal Protection Act	Advisory comments to Corps regarding impacts of projects on marine species.
U.S. Environmental Protection Agency (EPA)	Section 404(b) Clean Water Act	Comments to Corps on whether project is acceptable under 404(b) guidelines.
"	Section 404(c), 402 Clean Water Act	Veto of Corps permit action under certain circumstances

TABLE 8 (cont.)

STATE		
GOVERNMENT AGENCY	LEGAL AUTHORITY	PRIMARY RESPONSIBILITY
California Coastal Commission	Coastal Act of 1976	Regulation of development within coastal zone; Local Coastal Program (LCP) Amendments, particular concern with protection and, where feasible, restoration of coastal wetlands.
State Lands Commission	California State Construction Public Trust Doctrine	Regulation of activities in California's tidelands and submerged lands and lands subject to tidal influence in 1850
California Department of Fish and Game	Fish and Wildlife Coordination Act Public Resources Code, Section 1600-1603 Fish and Game Code California Endangered Species Act	Advisory comments to Corps regarding biological impacts of projects. Issuance of Streambed Alteration Agreements for development in any stream channel; endangered species consultation for State projects; regulation and management of game species and their taking; management of State Ecological Reserves.
California Dept. of Transportation	"	Grading and encroachment permit, Interstate 5

GOVERNMENT AGENCY	LEGAL AUTHORITY	PRIMARY RESPONSIBILITY
LOCAL		
County of San Diego Department of Parks and Recreation	Property owner Management authority for Dept. of Fish and Game	Staffs and manages reserve Reviews adjacent projects Seeks funds and grants
County of San Diego	Local police power municipal code zoning law Subdivision Map Act	Regulation of development within the County area. Development permits for park facilities, public access improvements. Grading and water course permits. Reviews and comments on vector control (mosquitos) through CEQA process; has power to enter private and public land for pest control.
San Diego Regional Water Quality Control Board (RWQCB)	Section 401 Clean Water Act; Porter Cologne Water Quality Act	Protection of water quality; certification of federally permitted activities that involve discharge of fill; preparation of regional water quality plans and standards; issuance of waste discharge permits.
City of Encinitas	Local police power municipal code zoning law Subdivision Map Act	Regulation of development within city limits. Amendments to LCP; rezoning; Resource Protection Overlay Zone Permit; various grading and encroachment permits.
	San Diego Northern Railway	Grading and encroachment permits, SDNR Railway

3. OPPORTUNITIES AND CONSTRAINTS FOR ENHANCEMENT

3.1 GENERAL COMMENT

The primary goal is to preserve and enhance a gradient of habitats that range from salt marsh in the west basin to freshwater marsh in the east basin. This will support a diverse ecosystem (including a healthy benthic community) and satisfy regional habitat needs with particular attention to those habitats important to multiple sensitive species.

In the existing state, there is insufficient tidal prism to maintain an open entrance to San Elijo Lagoon for more than brief periods. The broad, flat topography of the lagoon leads to prolonged periods of high water levels before natural breaching occurs. Currently mechanical management of the lagoon entrance is required to protect existing habitat from prolonged inundation and extended exposure to fresh water conditions.

The tidal hydrodynamic modeling revealed that dredging 107 acres would create the tidal prism necessary for the mouth to remain open permanently. However, the negative impacts of such a large amount of habitat loss would outweigh any positive impacts gained from creating a large tidal prism. Although the modeling can quantify the increase in tidal prism and amount of sediment transported out of the channels with a range of limited dredging options (less than 107 acres), it is unable to predict how long the mouth will remain open with each option. Therefore, it will be most beneficial to implement any program that increases the tidal prism in phases and includes monitoring of the biological and hydrological conditions of the lagoon as the tidal prism changes.

3.2 TIDAL HYDRODYNAMIC MODELING

Johnson's analysis (1976) estimates how large the tidal prism should be in order to maintain an open entrance to the lagoon under normal hydrologic conditions. Philip Williams and Associates (PWA) (1993) ran a computer model utilizing the tide elevation and velocity data collected in 1991 to evaluate the effects of different restoration options on lagoon openings. The goal of the modeling was to evaluate the relative improvement in tidal circulation if the tidal prism was increased by dredging or if the inlet channel was relocated. The Advisory Committee for the San Elijo Lagoon Enhancement Plan determined which dredging alternative (50 acres) to model based on biological constraints. A full discussion of the modeling methodology and analysis is contained in the Hydrology Appendix.

In addition, the PWA hydrologists were requested to model a range of dredging options for the existing lagoon inlet. A full discussion of this modeling is contained in the Hydrology Appendix. A brief summary of both modeling results follows.

3.2.1 Limited Dredging and Inlet Relocation

PWA simulated four different hydrologic conditions to compare restoration options: (1) the existing lagoon system (limited tidal prism and frequent lagoon mouth closures); (2) the existing lagoon system with limited dredging (50 acres) in the channel network within the lagoon; (3) the creation of a new lagoon inlet to replace the existing inlet; and (4) creation of a new inlet at an alternative location and limited dredging (50 acres) in the channel network.

The simulation showed that limited dredging with the existing inlet would increase the tidal prism by about 50 percent. Although this would maintain the mouth open for longer periods following a breach, there is no indication that a reduction in the cobble/sand bar formation could be expected with this alternative. Reduction of the cobble/sand bar is what leads to extended periods of open lagoon conditions.

The relocation of the lagoon inlet would eliminate the existing inlet flow constriction and allow a more natural width/depth ratio to develop. The simulation found that flows would increase along the entire channel and a deeper and wider inlet channel would remain open for longer periods of time, compared with the shallow channel formed under existing conditions.

The modeling found that if both relocation and network channel dredging were undertaken, the inflow would be much higher than if only dredging occurred. Peak outflow would also be increased. The circulation in the dredged portion of the lagoon would be greatly enhanced, since flow would move freely throughout the dredged area. The upstream areas of the lagoon would have slightly improved circulation compared to dredging alone, a result of the flow constriction of the railroad bridge. If the new inlet channel were not maintained, the expected reduction of water in the inlet area would tend to diminish peak channel outflows, by reducing the tidal prism volume available at lower tidal levels. Peak channel inflows would not be affected significantly.

The increase in velocities in the inlet channel due to increasing the tidal prism by dredging and/or realigning the inlet channel are significant, but the precise increase in the duration of lagoon opening depends upon the wave intensity, inlet channel configuration, and the presence of cobbles. The results of this preliminary modeling study show that there are significant hydrologic advantages to increasing the tidal prism and realigning the inlet channel. In 1994 and 1995 early summer cobble removal projects provided adequate tidal exchange. Cobble removal during this period allowed significant expansion of salt marsh vegetation.

3.2.2 Increased Tidal Prisms

In addition to simulating the existing condition and three restoration options described above, the PWA hydrologists were requested to model a range of dredging options based on the existing lagoon inlet. A range of increases in tidal prism was considered, from the existing potential mean tidal prism of 105 ac-ft. to 500 ac-ft. This latter tidal prism would be expected to maintain the lagoon open under normal hydrologic conditions, according to Johnson's criteria. The stability of the inlet channel was investigated for the diurnal tidal cycle that included the minimum tidal range in the mean tidal month (see Hydrology Appendix).

3.2.3 CONCLUSIONS OF MODELING

Several conclusions can be drawn from the PWA modeling. These fall into three general categories.

1. Cobble removal
Since it appears that the lagoon will be subject to periodic closure under any alternative that preserves the existing marsh plain and mudflat habitat, some form of inlet channel maintenance will be required. These measures could include:

- annual removal of cobbles in the area of the entrance to the inlet channel at the start of the summer season
- retroactive opening of the inlet by heavy equipment
- use of fluidizers, portable water jets, or traditional heavy equipment to maintain the inlet open before it closes (active management of the entrance)

2. Dredge
The Johnson criteria for maintaining an open inlet channel can be satisfied if 107 acres of land currently at an elevation of greater than 2.1 ft. NGVD is excavated to MLLW or less (approximately -3.5 ft. NGVD).

3. Alternate entrance
San Elijo Lagoon is flood-dominated for existing conditions and all dredging enhancements considered. Net inflow of beach sand exceeds net outflow. If an alternate inlet is considered as a viable alternative, the relocated inlet channel and final grading plan could be designed to ensure ebb-dominance or a net outward movement of sediment from the inlet channel under normal tide and flow conditions.

The US Fish and Wildlife Service-funded study that removed cobbles from the beach around the inlet channel documents the duration of lagoon opening with and without the presence of cobbles and under different wave climates. Data collected by the Pacific Estuarine Research Laboratory (San Diego State University) and Elwany (Scripps Institute of Oceanography) for other inlets such as Los Peñasquitos Lagoon and San Dieguito Lagoon during the proposed monitoring period can be used to generalize the conclusions. Both studies indicate that spring cobble removal significantly extends the period of time that the lagoon remains open to tidal exchange.

3.3 HYDROLOGICAL ENHANCEMENT OPPORTUNITIES

There are several opportunities to enhance the biological value and improve water quality by managing or altering the hydrology of San Elijo Lagoon to improve tidal exchange and circulation. Hydrological opportunities include:

1. Sand and Cobble Removal at Inlet

Retroactive opening of the inlet by bulldozing is the current management technique. Criteria and methods are described in section 2.4.3. The USFWS-funded studies for the springs of 1994 and 1995 included cobble removal at the mouth and subsequent monitoring of lagoon conditions. The results of these studies provided initial information on how long the inlet can remain open after cobble removal, and whether the biological and hydrological goals for San Elijo Lagoon enhancement can be met with channel maintenance alone.

2. Transportation Corridor Modification

Circulation in the lagoon could be improved by increasing the width of the bridges at each road or railroad crossing, or by creating additional channels through the embankments. This could be achieved by jacking a series of culverts through the embankment or constructing a causeway-type structure rather than the existing narrow bridges.

A. Widening Existing Railroad Trestle
Increasing the length of the trestle would allow storm flows to increase channel width and reduce flow constraints presented by the railroad berm.

B. Culverts through Railroad Berm
Culverts through the berm would allow multiple channels to connect the central and west basins, thereby increasing circulation, water quality, and aquatic life. It would also reduce the flow constraint of the railroad berm.

C. Widening Existing Interstate 5 Bridge/Overpass
Increasing the length of the bridge to the south would allow storm flows to increase channel width and pass through the central basin faster. It would reduce the flow constraint presented by the freeway fill and reduce the flooding of the east basin caused by storm flows backing up behind the fill.

D. Culverts through Interstate 5 Berm
Culverts through the berm would allow multiple channels to connect the East and central basins of the lagoon, thereby increasing circulation, water quality, and aquatic life. It would also reduce the flow constraint presented by the berm.

E. Widening Existing Highway 101 Bridge
Channel flow would be enhanced by widening the Highway 101 bridge and by relocating headwalls and pilings to reduce flow resistance and the extent of constraint to the channel. This would also allow some natural channel migration with storm flows, periods of low flow, and with seasonal fluctuations in longshore sand transport.

3. Channel Modification

The extent of tidal flushing could be increased by enlarging some of the marsh channels or increasing the network of channels. This would allow greater salinity intrusion along the channel and increase salinity levels adjacent to the channels when the lagoon is open to tidal action. As discussed in section 2.4.3, twice in recent years has it been necessary to remove material east of the Highway 101 bridge. The 1994 USFWS study preliminary findings indicate that this may be necessary every few years. Removal of accumulated silt, sediment, organic matter, and debris will reduce flow resistance and increase tidal prism.

4. Alteration of Tidal Prism

The periods of lagoon opening could be extended. This could be achieved in several different ways:

A. Replacement Inlet
Tidal exchange between the lagoon and ocean is inhibited not only by the small tidal prism, which is insufficient to maintain the entrance channel, but also by the constrained nature of the channel. An alternate opening could be created away from the reef, which would permit a deep channel to be scoured. This opening could be located south of the existing railroad bridge or at the southern end of the lagoon. This latter alternative would require an additional bridge for the San Diego Northern Railway, as well as a second bridge for Highway 101 and dredging to create a new inlet channel. This option could result in the lagoon being open for longer periods of time following a breaching of the barrier beach, and it would also result in improved tidal circulation in the lagoon. The computer model utilized by PWA simulated the flow patterns in the lagoon and quantified the changes in lagoon circulation made possible by a second inlet channel. This alternative would have high capital costs. Inlet location would be limited by State beach and private development projects adjacent to Highway 101, as well as by underground utilities.

B. Dredging
If some or all of the lagoon is dredged, the tidal prism could be increased. This could maintain the lagoon opening under normal wave and hydrologic conditions. Dredging will only increase the tidal prism if the elevation of the inlet is lower than the elevation of the dredged channel depth.

The computer simulation of a range of increased tidal prism conditions demonstrated that to maintain a permanently open inlet, 107 acres of land currently at an elevation of greater than 2.1 ft. NGVD would have to be excavated to MLLW or less (approximately -3.5 ft. NGVD). Because such a large amount of dredging would significantly reduce the existing salt marsh and mudflat communities, it is likely that a smaller dredging program would be more acceptable.

The computer simulation also demonstrated that there is a net movement of sediment into the inlet channel, which makes San Elijo Lagoon flood-dominated. To ensure ebb dominance (a net outward movement of sediment from the inlet channel under normal tide and flow conditions), the lagoon entrance must be lowered or the entire channel realigned (see "Creation of a Second Opening" below). The Hydrology Appendix discusses the computer model utilized and quantifies the amount of sediment transported with a range of dredging options. Table 9 presents a summary of dredging alternatives.

5. Desiltation Basins

There are potential benefits from constructing "first flush" ponds or desiltation basins on the freshwater inflow channels to protect the lagoon against sedimentation and urban runoff contaminants.

6. Excavation of Inlet

A sill of Del Mar claystone below the inlet would be considered a constraint to flow. Mechanical excavation of this sill, if it exists, would enhance flow, but natural channel scour may be sufficient to erode this relatively soft material. The extent and elevation of the sill has not been documented.

7. Improvements in Water Circulation Pattern

The sediment islands in the channel directly downstream from the Interstate 5 crossing (and resulting from this constriction) are an impediment to water flow in either direction. Significant elevation of salinity levels in the east basin could be achieved by the removal of these sediment islands. These islands are increasing in height and width by the ongoing trapping of sediment by the cattails and tules now growing there.

8. Installation of Groins or Breakwaters

Previous dike and fill activities (i.e.; sewage outfall and duck hunting club ponds) have resulted in impediments to free circulation. The breaching of these fill structures should result in

TABLE 9

SUMMARY OF DREDGING ALTERNATIVES

Case	Potential Mean Tidal Prism		Surface Area at MSL	Disturbed Area*	A_c	U_{MAX}	Sediment Flux during the Diurnal Tidal Cycle	Total Sediment Transported During the Tidal Cycle
	ac-ft	$x10^6ft^3$	acres	acres	(ft^2)	(m/s)	(tons)	(tons)
1	105	3.9	13.5	0	46	-0.98	0.003	0.735
2	198	8.6	38.5	25	144	-1.25	0.018	7.30
3	290	12.6	63.5	50	214	-1.26	0.038	15.840
4	383	16.7	88.5	75	286	-1.30	0.087	24.950
5	500	21.8	120.5	107	376	-1.32	0.142	36.560
6	290	12.6	63.5	50	214	-1.11	-0.0108	13.140
7	383	16.7	88.5	75	286	-1.05	-0.013	18.48
8	500	21.8	120.5	107	376	-1.01	-0.200	26.85
9	105	3.9	13.5	0	46	-1.22	0.0006	0.015
10	290	12.6	63.5	50	214	-1.11	0.0076	0.263

Note: Mean High Water is +2.1 ft NGVD
Mean Low Water is -1.6 ft NGVD

* Disturbed area assuming existing elevations are excavated to MLLW with steep slopes

improved water circulation. Littoral transport can be northwards or southwards at the entrance of San Elijo Lagoon, depending on the prevailing wind and wave conditions (Scott Englehorn, personal communication, 1991). Therefore, two groins, one on each side of the inlet, would need to be constructed. This alternative would be very expensive and would only be a temporary measure until the beach filled out to the end of the groin.

The interruption of longshore sediment transport processes would be a major concern to several regulatory agencies, particularly in relation to beach nourishment and shoreline erosion. Any adverse change in the surf break would cause considerable negative public reaction.

9. Sand Bypass

Sand bypassing techniques have been developed by the U.S. Army Corps of Engineers to pump longshore transported material across tidal inlets, and to maintain the inlets open for navigation purposes. There are several examples on the East Coast, and one local bypassing operation at Oceanside. This solution has been successful but has high capital, operating, and maintenance costs, and a source of funding would need to be identified.

10. Bed Fluidization

The inlets of some coastal lagoons and harbors are kept free of sediment by pumping water out of perforated pipes installed under the bed of the inlet channel. The water fluidizes the overlying material, allowing sediment to be transported more easily on ebb currents, which keeps the inlet channel clear. This technique would have limited success at San Elijo due to the high proportion of cobbles in the barrier beach, which closes the tidal inlet. Therefore, it would be most effective to combine this technique with cobble removal. Public use of the area would preclude this option if sand fluidization results in safety hazards.

11. Pulsing

If the discharge of water from the lagoon to the ocean occurs when the difference in water surface elevation across the inlet channel is greatest, the maximum erosion of the inlet channel will occur. This could be achieved by "pulsing" freshwater flows through the lagoon (a concept proposed by Zedler, San Diego State University), or designing a grading plan to maximize the differential water surface elevation across the tidal inlet. In the latter alternative, deep areas of the lagoon would be designed to ensure that the lag between tidal elevations in the lagoon and ocean were such that the scouring action in the inlet channel was maximized. Analyses of these alternatives would require a tidal hydrodynamic model. However, it is not clear where this water could be stored without damage to existing natural resources. If the storage area is too far upstream, the pulsing action would be difficult to synchronize with the tides.

3.4 BIOLOGICAL ENHANCEMENT OPPORTUNITIES

There are many opportunities to enhance the biological resources of the San Elijo Lagoon system (Figure 3.1). Combined with feasible hydrological improvements, these biological enhancements would help meet the biotic goals for the lagoon (Table 10). Recommended biological improvements include:

1. Establish a regime of frequent tidal exchange. This would benefit lagoon biota in the following ways:
   a. restore the estuarine mudflat environment, providing food and forage for the wildlife;
   b. improve conditions for halophytic plants now submerged under brackish/fresh water for months;
   c. discourage intrusion of freshwater plant species (cattails, etc.) which cause significant problems with water flow and channel blockage;
   d. reduce effects of pollution to the estuarine inhabitants from upstream sources by allowing said pollutants to flow into ocean;
   e. improve water quality to benefit aquatic organisms and species diversity;
   f. improve oxygen levels and reduce extreme fluctuations to benefit fish and benthic invertebrate species and the fish and bird species that feed on them;
   g. restore shallow nursery areas for marine organisms, thereby increasing numbers of offshore fish;
   h. reduce pest insect species in the central and west basins, thereby reducing citizen complaints;
   i. reduce beach closure and environmental disruption; and
   j. reduce possibilities of algal blooms and eutrophication and associated odors.

2. Enhance and restore native plant communities in the following ways:
   a. introduce or enhance populations of extirpated species;
   b. remedy the cause of extirpation of sensitive species, e.g., restore tidal influence to allow survival of salt marsh bird's beak (*Cordylanthus)* and cordgrass (*Spartina)*;
   c. revegetate areas impacted by overgrazing, farming, erosion, trails, or other visitor-related activity. Close trails that are redundant or impact sensitive habitat areas.;
   d. introduce or augment existing populations of plant species on the Federal, State, or CNPS sensitive list with the goal of perpetuation of the species;
   e. enhance habitat to benefit sensitive animal species; and
   f. remove exotic vegetation such as iceplant, pampas grass, *Arundo donax,* and acacia. Remove eucalyptus from riparian areas and replace with native trees.

Exhibit 3: San Elijo Lagoon Area Enhancement Plan

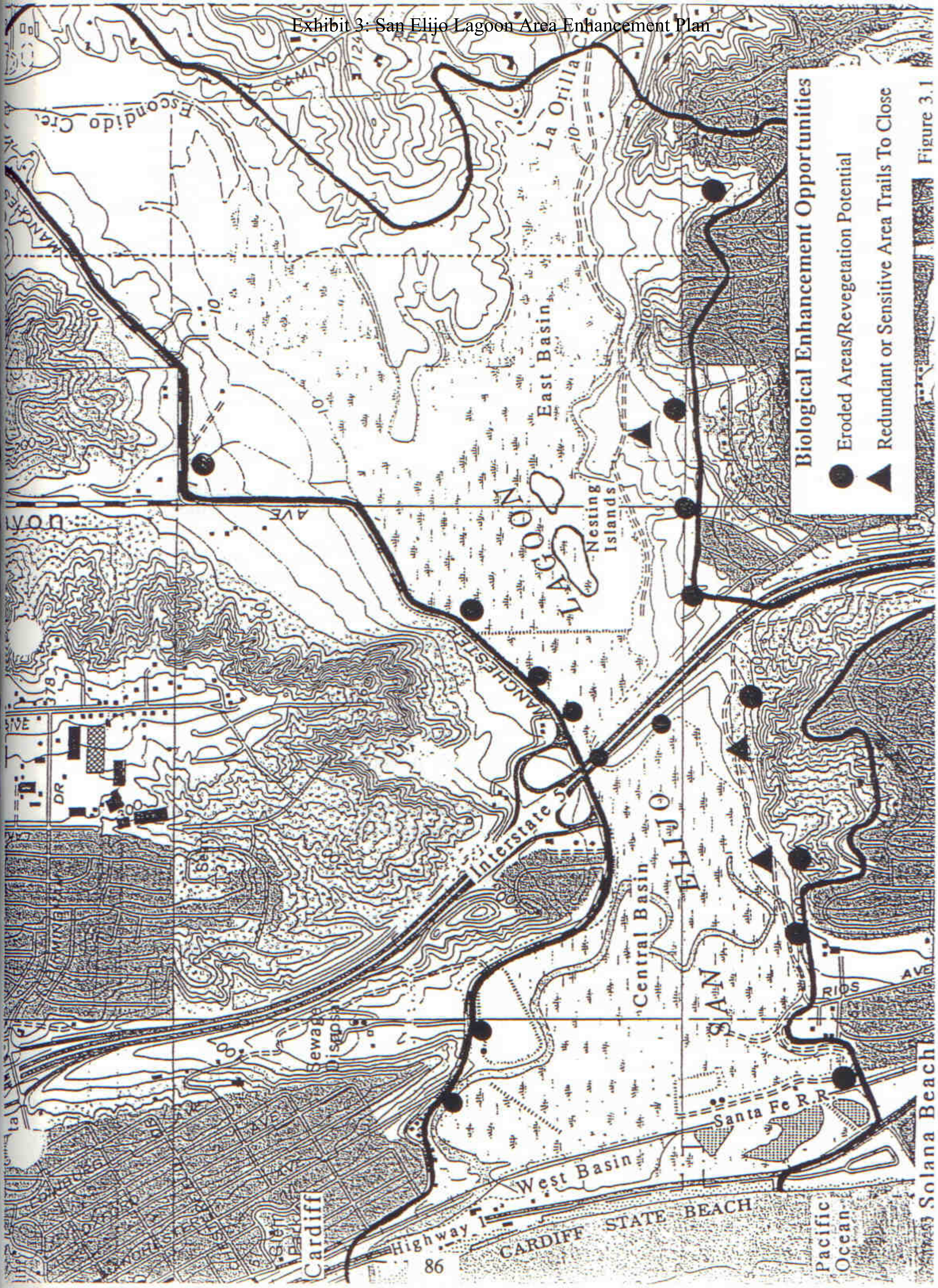


TABLE 10. SUMMARY OF ENHANCEMENT BENEFITS

Regular tidal exchange would result in:

1. Hydrological Improvements
   - regularly fluctuating water levels within a limited range of surface elevations
   - exchange of water in lagoon basins
   - increased and regular channel scour
   - increased seawater inflow to lagoon
   - increased sand supply to beach
   - increased water circulation and flow
   - channel and flow constrictions reduced by scour and death of freshwater and non-native plants in channels
   - reduce impact of siltation and sedimentation
   - increase future possibility of re-opening inlet

2. Water Quality Improvements
   - increased dissolved oxygen levels and reduce range of fluctuation
   - increased salinity and reduce range of fluctuation
   - reduced impacts of pollution by dilution and water exchange with ocean
   - reduced bacteria load by dilution, saltwater plasmolysis, and water exchange with ocean
   - reduced nutrient load and organic debris
   - reduced turbidity
   - increased recovery time after sewage spill or storm flow events
   - reduced chance of eutrophication

3. Biological Improvements
   - increased offshore fish populations by increasing nursery habitat
   - stabilization of aquatic and marsh plants and communities
   - increased plant diversity
   - enhanced salt marsh and aquatic plant health
   - improved and increased shorebird and endangered species habitat, increased diversity and abundance
   - reduced degradation of salt marsh by invading non-native and freshwater plants
   - reduced chance of catastrophic invertebrate and fish kills
   - increased chance of re-establishing now excluded species such as sensitive and sedentary invertebrates, fish, and endangered plant species

TABLE 10 (cont.)

4. Public Services and Safety Improvements
   Improved recreation, including:
   - reduced frequency of trail and beach closures
   - providing warm sheltered shallow water
   - increased sand on state beach
   - improved water quality
   - reduced odors improving state beach camping and support from adjacent landowners
   - increased game fish populations and diversity of accessible species
   - reduced nuisance midge populations
   - allowing predictable environmental education programs geared to estuarine habitats
   - reduced health risk of bacteria and mosquito populations
   - reduced administrative time on permits, scheduling, and dealing with complaints of health and nuisance problems

3. Recommend management (i.e., encouragement) programs for sensitive species. Although these programs are usually addressed specifically toward a single species, other species using the habitat would benefit. To provide habitat most favored by threatened or endangered species, in an effort to encourage their use of the reserve, the following guidelines for habitat enhancement are recommended:

Coastal cactus wren (Fed. Cat. 2)
Suitable south and west facing slopes on the mesa at the eastern end of the reserve could be planted with cuttings from existing coastal cholla. Eventual goal is impenetrable clumps of cholla 5 - 10 meters across.

Least Bell's vireo (Fed. Endangered)
Encourage riparian growth by planting willows, sycamores, cottonwoods, and understory shrubs to enhance existing riparian areas. Thin out same-age ("dog-hair") willow thickets to provide low and medium growth rather than tall closed canopy. Discourage exotic vegetation in riparian areas. Discourage human activities in riparian area (transients, trails, etc.).

Light-footed clapper rail (Fed. Endangered)
If tidal activity is restored, the intensive planting of cordgrass and introduction of California horn snail and other native salt marsh mollusks are recommended. This would also benefit the black rail (Fed. Cat 2). If the freshwater situation persists, the clapper rail may continue to use the cattail and tule thickets in the east basin. Any plan for cattail control in the east basin should be aware of the use of this habitat by rails.

California least tern (Fed. Endangered), *snowy plover* (Fed. Threatened)
No planting program - the success of these species might be improved by:

a) widening and deepening islands' moat east of I-5, and by removing cattails to reduce predator cover;
b) importing sand to islands to improve nesting sites;
c) fencing or otherwise precluding swimming predators;
d) examining central basin for potential island nest sites;
e) removing non-native species and fencing remnant dune area of west basin;
f) enhancing tidal exchange to improve prey base for foraging;
g) reducing populations of known predators in nest areas (e.g., ravens, raccoons); and
h) reducing predator perches such as non-native trees adjacent to nesting areas.

Belding's savannah sparrow (State Endangered, Fed. Cat. 2)
Salicornia should be encouraged in any suitable spot. Fencing should be considered in some

problem areas to reduce off trail visitor impacts. Tidal exchange would increase habitat health and diversity and increase food base.

California gnatcatcher (Fed. Cat. 2)
Encourage dense and continuous thickets of coastal sage scrub, dominated by *Artemsia californica,* and discourage human and pet activity in known nesting areas. Eliminate redundant trails and discourage off-trail activity. Repair damaged and inadequate storm drains along southern reserve boundary that cause significant erosion in sage scrub areas. Monitor for predators and parasites (cowbirds) with the possibility of trapping programs.

3.5 CONSTRAINTS TO ENHANCEMENT

The major constraint to effective enhancement of the lagoon system is the presence of man-made obstructions. Fill material for Highway 101, the San Diego Northern Railway, Interstate 5 and the east basin flood control dike inhibit and modify the natural workings of the hydrologic system to such an extent that any efforts to return the system to a natural state will be seriously handicapped. The ideal solution would be to remove these impediments, either entirely or by replacement with bridges.

As it exists now, the nature of the study site and manmade changes to the physical characteristics of San Elijo Lagoon impose several constraints on potential enhancements and will restrict the type of habitat that can be created. Significant constraints are:

Hydrological Constraints

- The road and railway embankments divide the study site into distinct basins. These physical features restrict flow circulation and create three water bodies connected by small channels at the bridges. In addition, the fill footprint of these obstructions eliminates many acres of marsh habitats. The sediment eroded from and trapped by these features constrains the creation of tidal marsh as the elevation of the marsh floor rises.

- Highway 101 and the railroad embankments impose a narrow, confined channel at the lagoon inlet. The protected embankments at the inlet restrict lateral scour and downcutting of the channel. This confined channel controls the rate at which water can be discharged from the lagoon, and restricts the tidal prism (refer to Section 2.2).

- The long-term maintenance of the lagoon entrance is limited by substantial longshore transport, which can be in a southward or northward direction. The barrier beach contains cobbles that are difficult to transport at low outflow velocities.

- The geological formations of the shoreline at the lagoon's confined inlet may inhibit downcutting of the channel. The Philip Williams study proposed the presence of a "rock sill" at the lagoon inlet. This has never been observed in the lagoon mouth. The formation refracts waves north of the channel, altering the angle of wave break (the "Cardiff Reef").

- There is a limited and intermittent flow of fresh water into the lagoon. Freshwater discharge is insufficient to overcome longshore sand transport and maintain an open channel. If the lagoon contains a large volume of water prior to breaching, the entrance channel will scour and maintain tidal flows for up to one month. (Opening duration is also affected by winter tides and storms.) Introduction of large volumes of fresh water helps to keep the mouth open, but would be detrimental to the estuarine ecology if the mouth was closed.

- The commercial establishments on Highway 101 and the State Park campground and parking lot constrain the shape and alignment of the inlet channel.

- Pilings and bridge footings at Highway 101 constrain dredging and channel width where Highway 101 crosses the channel.

- Buried utility lines and pipelines for sewer, natural gas, and water limit dredging options.

- There is evidence of accelerated sedimentation since the construction of road and railway embankments and dikes in the lagoon. Sedimentation reduces the tidal prism by raising the elevation of the marsh plain, which reduces the depth of water in the lagoon.

- The destructive potential of major storm events should be kept in mind, since a significant flood event could damage any restored area.

Biological Constraints

- As the surrounding areas have urbanized, conflicts have increased between recreational and urban needs and sensitive biological needs. Lagoon habitats have been fragmented by trails and road and utility easements; upland habitats have been degraded by off-road vehicle activity, increased frequency of fires, and accelerated spot erosion from storm drains. Wildlife predation and transmission of diseases by pets has increased. It is likely that future demands will increase for insect control, fire breaks, active recreation, and protection from perceived public hazards such as coyotes, rattlesnakes, and ticks.

- Exotic plant species have displaced native vegetation in both lagoon and upland habitats. Degradation of the salt marsh habitat in the lagoon has allowed establishment of exotic and atypical native plant species. Non-native animal species compete with and prey upon native species. However, removal of exotic plant and animal species may be constrained by public opinion, due to the need for trapping programs, herbicide application, etc.

- County funding shortages have threatened to eliminate ranger supervision of the area, which would jeopardize the success of any enhancement efforts requiring ongoing maintenance and management.

- Enhancement affecting any sensitive species is regulated by law, even if the ultimate outcome is beneficial. For example, cattail removal could impact light-footed clapper rails, although improved water circulation would ultimately benefit them. Dredging to increase tidal prism could impact avian nesting or foraging habitats if salt panne or salt marsh is removed.

- Removal and disposal of dredged material is constrained by biological, financial and legal factors; wetlands cannot be filled, dredged material may not be suitable for disposal on the adjacent beach, etc.

3.6 OPPORTUNITIES FOR ADDITIONAL STUDIES

- Develop new funding sources for studies, acquisition, and management activities.

- Continued monitoring of hydrological and biological baselines.

- New studies or inventories of under-examined areas: i.e., invertebrates, insects, reptiles, etc.

- Develop education programs for all class levels to allow sensitive use of the reserve by local schools.

- Determine sources and movements of beach cobble.

- Determine if mudflats have been raised to a less than optimal height by sedimentation, and if so, how best to correct the problem.

4. RECOMMENDED PLAN

Many options with widely varying levels of cost, practicality, and probable success have been discussed. The San Elijo Lagoon Enhancement Plan advisory group chose and prioritized several options to pursue, with the thought that the strategy would continue to evolve as more information was accumulated.

4.1 MANAGEMENT STRATEGY

The recommended plan of action is a tiered approach to restoration and enhancement:

Phase I (in progress):

a. Continue existing management and augment monitoring program.

b. Continue to periodically remove cobble berm mechanically to maintain open mouth (1994 and 1995 USFWS projects).
c. Biological enhancement (i.e., removal of non-native invasive species).
d. Improve and refine public access; public information brochures; sign program, interpretation, parking.
e. Identify further studies needed and funding sources.

Phase II:

a. Evaluate success of phase I.
b. Undertake additional actions if feasible, as needed, and as funding is secured, including but not limited to:
   · lengthen span of Highway 101 and Interstate 5 bridges, resulting in a widening of the channels
   · retrofit of railroad berm and I-5 berm with tunnels for water and wildlife
   · limited dredging in existing channels to deepen channels
   · relocate lagoon mouth and inlet channel
   · investigate groins and breakwaters

4.2 ADDITIONAL RECOMMENDATIONS:

1. The freshwater inflow to San Elijo Lagoon could be monitored more accurately if an ALERT stream gauging station were installed in the lower reaches of Escondido Creek. Data collected from a new gauging station would be short-term, but trends could be extrapolated by correlating with longer term records for Escondido Creek at Harmony Grove Road and Lake Wohlford. This action requires a funding source.

2. Existing monumented cross-sections in the central and west basins should be monitored to provide data on sedimentation rates following any significant flow events.

3. A salinity model could supplement the hydrodynamic model to determine where the extent of the salt marsh habitat might stabilize for given enhancement alternatives.

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(8) Firearms. No person shall fire or discharge any firearm, bow and arrow, air or gas gun, spear gun, or any other weapon of any kind within or into an ecological reserve or possess such weapons within an ecological reserve, except law enforcement personnel and as provided for in individual area regulations that allow for hunting.

(9) Ejection. Employees of the department may eject any person from an ecological reserve for violation of any of these rules or regulations or for any reason when it appears that the general safety or welfare of the ecological reserve or persons thereon is endangered.

(10) Public Entry. Public entry may be restricted on any area at the discretion of the department to protect the wildlife, aquatic life, or habitat. No person, except state and local law enforcement officers, fire suppression agencies and employees of the department in the performance of their official duties or persons possessing written permission from the department, may enter any ecological reserve, or portion thereof, which is closed to public entry. No person may enter any Ecological Reserve between sunset and sunrise except with written permission from the Department which may be granted for purposes including night fishing in accordance with subsection 630 (a) (2) from designated shore areas only.

A $2.00 day use pass or a valid $10.00 annual wildlife pass is required of all users of Elkhorn Slough and Upper Newport Bay ecological reserves except for users that possess a valid California sport fishing license hunting license or trapping license, or users that are under 16 years of age or users that are part of an organized youth or school group and having free permits issued by the appropriate regional office. Refer to section 550 (b) (16) (B), title 14, CCR for regulations for fee requirements for wildlife areas.

(11) Introduction of Species. Unless authorized by the commission, the release of any fish or wildlife species, including domestic or domesticated species, or the introduction of any plant species, is prohibited. The department may reintroduce endemic species on ecological reserves for management purposes.

(12) Feeding of Wildlife. The feeding of wildlife is prohibited.

(13) Pesticides. The use of pesticides is prohibited on any ecological reserve unless authorized by the commission.

(14) Litter. No person shall deposit, drop, or scatter any debris on any ecological reserve except in a receptacle or area designated for that purpose. Where no designated receptacles are provided, any refuse resulting from a person's use of an area must be removed from that area by such person.

(15) Grazing. The grazing of livestock is prohibited on any ecological reserve.

(16) Falconry. Falconry is prohibited.

(17) Aircraft. No person shall operate any aircraft or hovercraft within a reserve, except as authorized by a permit from the commission.

APPENDIX A

CALIFORNIA DEPARTMENT OF FISH AND GAME ECOLOGICAL RESERVE REGULATIONS

CHAPTER 11. ECOLOGICAL RESERVES

The areas specified in this chapter have been declared by the Fish and Game Commission to be ecological reserves. A legal description of the boundaries of each ecological reserve is on file at the department's headquarters, 1416 Ninth Street, Sacramento. Ecological reserves are established to provide protection for rare, threatened or endangered native plants, wildlife, aquatic organism and specialized terrestrial or aquatic habitat types. Public entry and use of ecological reserves shall be compatible with the primary purposes of such reserves, and subject to the following applicable general rules and regulations, except as otherwise provided for in the special area regulations:

(a) <u>General Rules and Regulations:</u>

(1) <u>Protection of Resources.</u> No person shall mine of disturb geological formations or archeological artifacts or take or disturb any bird or nest, or eggs thereof, or any plant, mammals, fish, mollusk, crustacean, amphibian, reptile, or any other form of plant or animal life in an ecological reserve except as provided in subsections (630) (a) (2) and (a) (8). The department may implement enhancement and protective measures to assure proper utilization and maintenance of ecological reserves.

(2) <u>Fishing.</u> Fishing shall be allowed in accordance with the general fishing regulations of the commission except that the method of taking fish shall be limited to angling from shore. No person shall take fish for commercial purposes in any ecological reserve except by permit from the commission.

(3) <u>Collecting.</u> No collecting shall be done in an ecological reserve except by permit issued pursuant to section 650 of these regulations. Any person applying for a permit must have a valid scientific collecting permit issued pursuant to part 3 of this title.

(4) <u>Motor Vehicles.</u> No person shall drive, operate, leave, or stop any motor vehicle, <u>bicycle</u>, tractor, or other type of vehicle in an ecological reserve except on designated access roads and parking areas.

(5) <u>Swimming.</u> No person shall swim, <u>wade</u>, dive, or use any diving equipment within an ecological reserve except as authorized under the terms of a permit issued pursuant to subsection (3).

(6) <u>Boating.</u> No person shall launch or operate a boat or other floating device within an ecological reserve except by permit from the commission.

(7) <u>Trails.</u> The department may designate areas within an ecological reserve where added protection of plant or animal life is desirable, and may establish equestrian or walking trails or paths within such designated areas. No person shall walk or ride horseback in such areas except upon the established trails or paths.

(18) Pets. Pets, including dogs and cats, are prohibited from entering reserves unless they are retained on a leash of less than ten feet or are inside a motor vehicle.

(19) Fires. No person shall light fireworks or other explosive or incendiary devices, or start or maintain any fire on or in any reserve, except for management purposes as provided in subsection (a) (1).

(20) Camping. No person shall camp on/in any ecological reserve.

(21) Vandalism. No person shall tamper with, damage or remove any property not his own when such property is located within an ecological reserve.

(46) San Elijo Lagoon Ecological Reserve, San Diego County,

(A) Notwithstanding the provisions of subsections (a) (1), (3), (5), (6) and (12), the department may issue permits to conduct biological research projects within the reserve. Such projects shall be compatible with the primary purposes of the reserve.

(B) The department and San Diego County may carry out management activities for fish and wildlife management, flood control, vector control and regional park recreational activities. Authorized operation and maintenance activities shall include, but shall not be limited to, use of chemicals, vegetation control, water control, minor ditching and use of associated equipment.

(C) Collections may be made by the department for purposes of wildlife management or by San Diego County for the purpose of water quality testing and vector control.

APPENDIX D

SUMMARY OF LAGOON OPENINGS

Date of Opening	Date of Closure	Days Open	Natural/Artificial	Water Level	Comments
10-22-86	10-27-86	5	Artificial		
12-15-86	12-26-86	11	Artificial	5.5+	
01-07-87	01-13-87	6	Natural	5.4	
03-04-87	03-12-87	8	Artificial		
04-06-87	04-13-87	7	Artificial		
08-03-87	08-18-87	15*	Artificial		
11-05-87	11-11-87	6	Artificial		
02-02-88	02-11-88	9	Natural		
04-06-88	04-11-88	5	Artificial		
04-22-88	04-29-88	5	Natural		
05-23-88	05-26-88	3	Artificial		
12-12-88	12-18-88	6	Artificial		
12-25-88	01-26-89	32	Natural		
02-04-89	02-08-89	4	Artificial		
04-01-89	04-11-89	10	Natural	5.8+	
05-09-89	05-10-89	1	Artificial		
10-16-89	10-16-89	<1	Artificial		
02-01-90	02-12-90	11	Natural	6.7	
02-19-90	03-04-90	13	Natural		
04-30-90	05-03-90	3	Artificial	5.35	Channel excavation: artificially closed
05-14-90	06-30-90	45*	Artificial		Excavation east of Highway 101
09-27-90	09-28-90	1	Artificial	2.6	
12-17-90	12-20-90	3	Artificial	3.25	
02-25-91	04-10-91	37	Artificial	5.0	
04-16-91	04-26-91	10	Natural		

APPENDIX D (cont.)

05-15-91	05-20-91	5	Artificial		
08-05-91	08-07-91	2	Artificial	3.0	
09-09-91	09-09-91	<1	Artificial	3.0	
01-09-92	02-06-92	28	Natural	8.05	
03-04-92	03-10-92	6	Natural	4.3+	
04-01-92	04-27-92	26	Natural	6.72	
05-18-92	05-21-92	3*	Artificial	3.29	
08-04-92	08-06-92	2	Artificial		
12-14-92	04-04-93	111	Artificial	4.96	
04-12-93	04-17-93	5	Artificial	4.37	
05-11-93	05-15-93	4	Artificial		
06-06-93	07-10-93	34*	Artificial	3.88+	
10-16-93	10-29-93	13*	Artificial	3.57	
02-08-94	04-01-94	52	Natural	7.3	
04-19-94	08-23-94	127	Artificial		Cobble removal west of Highway 101

*Channel maintained open artificially - Source: County of San Diego Parks Department

APPENDIX D (cont.)

	No. of Openings	Days open	Water level	No. of openings	Days open	water level
Jan	2	6-28	5.4-8.05		?	?
Feb	4	9-52	6.7-7.3	2	4-37	?-5.0
Mar	1	6	4.3+	1	8	?
Apr	4	5-26	5.8-6.72	5	3-127	?-5.35
May	-			6	1-45*	3.29-?
Jun	-			1	34*	3.88+
Jul	-			-		
Aug	-			3	2-15*	3.0-?
Sept	-			2	<1-1	2.6-3.0
Oct	-			3	<1-13	3.57-?
Nov	-			1	6	?
Dec	1	32	?	4	3-111	3.25-5.5+